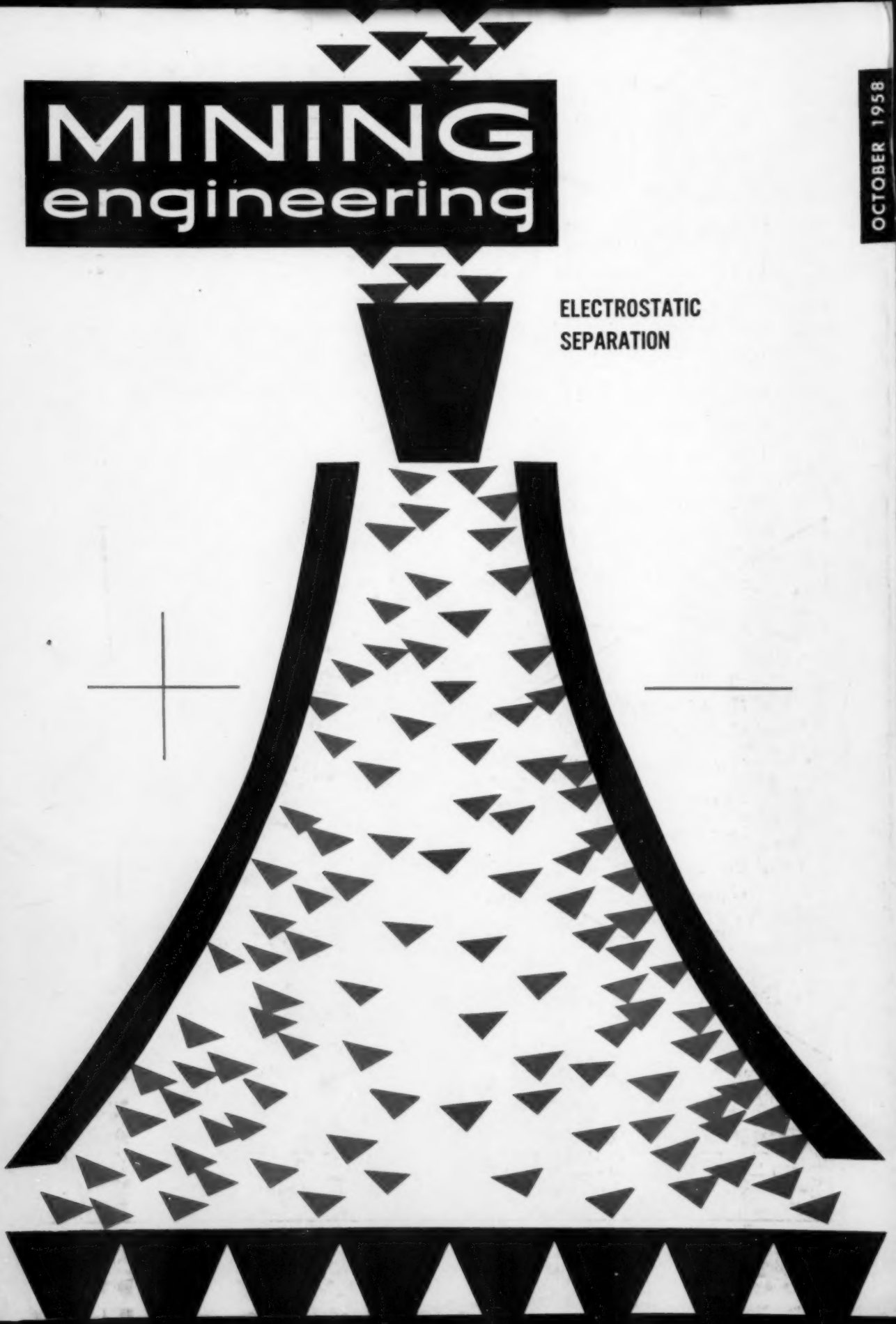
MINING engineering

OCTOBER 1958

ELECTROSTATIC SEPARATION



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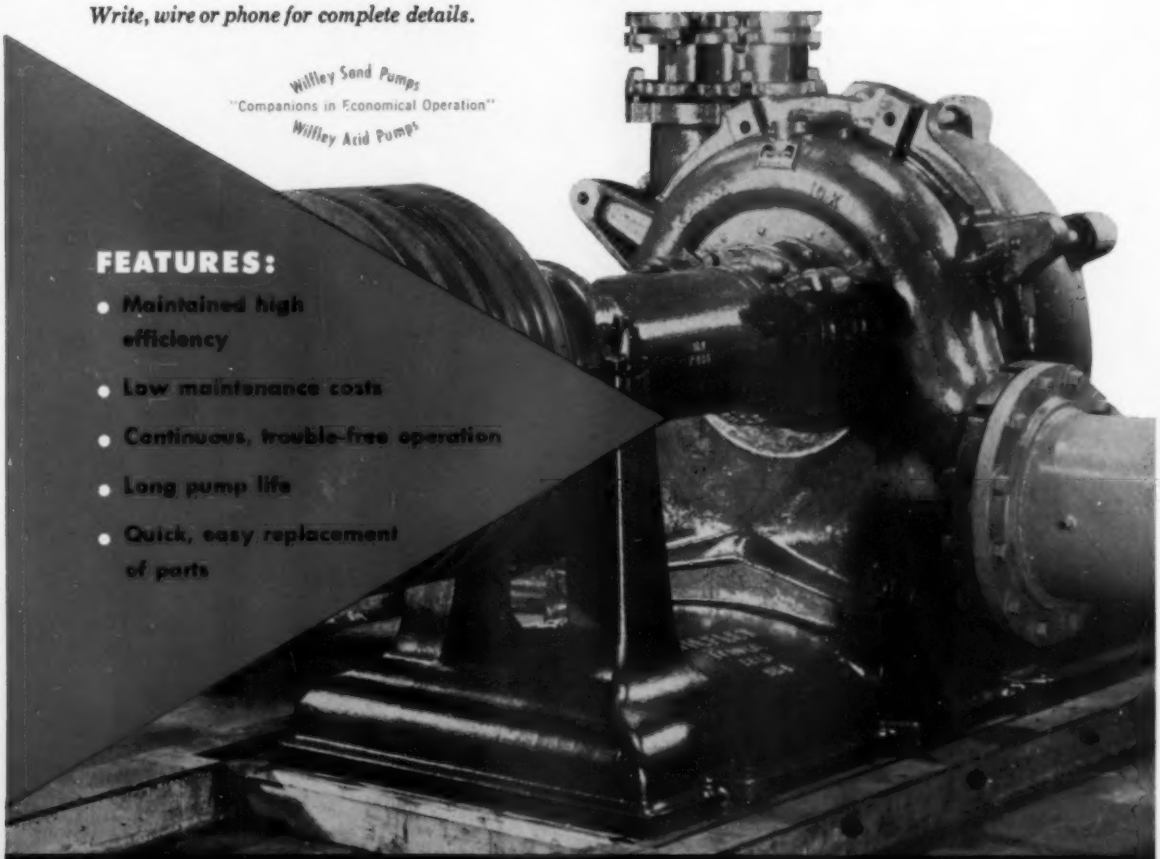

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COMING EVENTS

Oct. 9-10, AIME-ASME Solid Fuels Conference, Hotel Chamberlin, Old Point Comfort, Va.

Oct. 9-10, ECPD annual meeting, Sheraton-Jefferson Hotel, St. Louis.

Oct. 13-16, Soc. of Exploration Geophysicists, annual meeting, Gunter Hotel, San Antonio, Texas.

Oct. 15-17, Energy Resources Conference, Brown Palace Hotel, Denver.

Oct. 16, AIME Utah Section, speaker: L. V. Olson; subject: Progress in Air Pollution Control; Salt Lake City.

Oct. 16-18, 9th Annual Field Conference, New Mexico Geological Soc. in cooperation with Arizona Geological Soc., Black Mesa Basin of northeastern Arizona.

Oct. 17, Appalachian Geological Soc., Pittsburgh Geological Soc., joint meeting, Mont Chateau Lodge near Morgantown, W. Va.

Oct. 20-23, National Clay Conference, Natural History Bldg., Smithsonian Inst., Washington, D. C.

Oct. 23-25, AIME Mid-America Minerals Conference, Chase-Park Plaza Hotels, St. Louis.

Oct. 24, AIME Lehigh Valley Section, technical meeting, Hotel Traylor, Allentown, Pa.

Oct. 24, AIME Pennsylvania-Anthracite Section, fall meeting, Mayfair Night Club, Wilkes-Barre, Pa.

Oct. 31-Nov. 1, AIME Central Appalachian Section and West Virginia Coal Mining Inst., joint meeting, The Greenbrier, White Sulphur Springs, W. Va.

Oct. 30-Nov. 1, International Mining Days, New Mexico Mining Assn. and Southwest International Mining Assn., Carlsbad, N. M.

Nov. 7, AIME Pittsburgh Section and AIME NOHC Pittsburgh Section, 13th annual Off-the-Record Meeting, Principal speaker: G. B. Warren, General Electric Co.; Penn-Sheraton Hotel, Pittsburgh.

Nov. 13-14, Missouri School of Mines and Metallurgy, 4th annual symposium on mining research, University of Missouri, Rolla, Mo.

Nov. 14-15, AIME Southeast Section, annual fall meeting, Atlanta.

Nov. 18, AIME Ohio Valley Subsection, President's night—guest: Augustus B. Kinzel; Ricardo's, Columbus, Ohio.

Dec. 1, AIME Arizona Section, annual meeting, Pioneer Hotel, Tucson, Ariz.

Dec. 5, AIME Lehigh Valley Section, ladies' night, Speaker: Augustus B. Kinzel; Lehigh Valley Club, Allentown, Pa.

Dec. 6, AIME Eastern North Carolina Subsection, Southeast Section, Hotel Vance, Henderson, N. C.

Dec. 11, AIME Utah Section, panel discussion on Place of Research in the Minerals Industries; members: chairman J. M. Ehrhorn, S. R. Zimmerley, J. B. Clemmer, W. M. Fassell, Jr., J. R. Lewis; Salt Lake City.

Jan. 5-9, 1959, 2nd Caribbean Geological Conference, University of Puerto Rico and Economic Development Administration of the Commonwealth of Puerto Rico, sponsors; University of Puerto Rico, Mayaguez, P.R.

Jan. 12, AIME Minnesota Section, annual meeting, Duluth.

Jan. 13-14, Annual Mining Symposium, University of Minnesota, Duluth.

Feb. 5-6, California Governor's Industrial Safety Conference, Biltmore Hotel, Los Angeles.

Feb. 5-7, Centennial Celebration and Mining Convention, sponsored by Colorado Mining Assn. and others, Denver.

Feb. 15-19, AIME Annual Meeting, Sheraton-Palace, St. Francis, Sir Francis Drake Hotels, San Francisco.

Apr. 5-10, EJC 1959 Nuclear Congress, Public Auditorium, Cleveland.

Apr. 18, AIME Colorado MBD Subsection, Broadmoor Hotel, Colorado Springs, Colo.

MINING engineering

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COVER *Electrostatic separation as a dry beneficiation process for industrial minerals seems to offer advantages over other methods. Artist Herb McClure diagrams the basic step in the process on this month's cover, see page 1081.*

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PERSONNEL

THE following employment items are made available to AIME members on a nonprofit basis by the Engineering Societies Personnel Service, Inc (Agency) operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 8c in stamps (no stamped envelopes) for forwarding and returning application. The applicant agrees, if placed in a position by means of the Personnel Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter or $12 a year.

MEN AVAILABLE

Chief Metallurgist, metallurgical engineer, M.S., D.Sc. in metallurgical engineering, age 32. Five years experience in mineral industry research with leading research foundation. Three years metallurgical engineer with mining company in charge of plant control and research. Location, immaterial. M-438.

Geologist, A.B., age 32. Four and one half years experience in mining exploration geology including mapping, drilling, development, and evaluation. Prefer eastern U. S. M-439.

Mine Engineer, B.S., age 27. Four years experience major Pb-Zn producer, surveying and mapping, surface and underground. Prefer foreign location. #1875-San Francisco.

Office Engineer or Cost Studies, E.M., age 62. Top management, industrial minerals (limestone). Twenty-one years with last company. Prefer San Francisco Bay area. #1882-San Francisco.

Coal Preparation Engineer, desires employment in coal industry. B.S. in mining, M.S. in mineral dressing, plus seven years experience in coal preparation. Experience includes management, supervision, engineering design, construction, coal chemistry, and trouble shooting in coal preparation plant. Plant experience includes heavy media, Rheo Laveur, Chance cone and jig, plus all fine coal cleaning equipment. Presently employed. M-440.

POSITIONS OPEN

Assistant to Chief Engineer, B.S. in mining or metallurgical engineering, under 50, with ten years experience in mine plant and metallurgical plant engineering, mine and metallurgical operations. Knowledge engineering, mining, metallurgy, administration. Will act as administrative assistant to chief engineer for personnel, cost control, and special assignments and studies. Traveling, no car required. Salary, up to $14,000. Location, western U. S. C6909.

Mine Superintendent, with production and management experience in mining of uranium ore to take charge of 100-tpd operation at 50,000 to 100,000 tons proven property. Salary, $9000 per year plus living quarters. Location, Arizona. W6504.

Field Sales Engineer, degree in metallurgy or minerals beneficiation preferred, for multi-division company. Will be responsible for process equipment sales to the metallic and nonmetallic industries. Must have three to five years experience in processing equipment field. Liberal benefits with good starting salary plus incentive based directly on sales efforts. Car furnished and expenses paid. Territory, northeastern territory out of New York. W6330.

Mining Engineer, registered, for civil engineering work in conjunction with new central cleaning plant for coal mining, 15,000 tpd. Upon completion of plant would be transferred back to mines as chief of the engineering department for two new mines now in development stage; mines will be 5000-tpd fully mechanized operation. Salary, $7,800 year to start; when transferred to mine, $10,800 a year to start. Location, South. W6024.

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LETTERS

Small Operator's Headache

(*Ed. Note:* This letter was received from a member in Nevada recently. The Secretary's reply appears below.)

I am very happy to inform you that I am at last able to forward my long delinquent dues and did so this morning under separate cover. I have felt terribly about this matter and really wanted to write before this and ask for grace. But always I have thought that perhaps next week or so I would be able to pay my dues and not have to make such a request. As the weeks have grown into months this has become more and more a concern to me, for I sincerely want to remain an active member of the Institute and the Society in particular. The arrival of your letter is coincident with the first run of good work I have had this year, and I certainly look forward to being a member in good standing again.

I know that you are well aware of the general lethargy in mining, but the plight of the very small operator is such that few understand it. As difficulty has pyramided to impossibility, the ranks of the 'ham and eggers' are so depleted that the category is almost relegated to history. I am more fortunate than most, perhaps, in being as well accomplished in the practical as trained in the technical. To be able to use a muck stick or a slip stick with equal facility is largely the reason that I am still going as an independent. This involves a lot of hard work and presupposes an avowed faith in the future of the small operator.

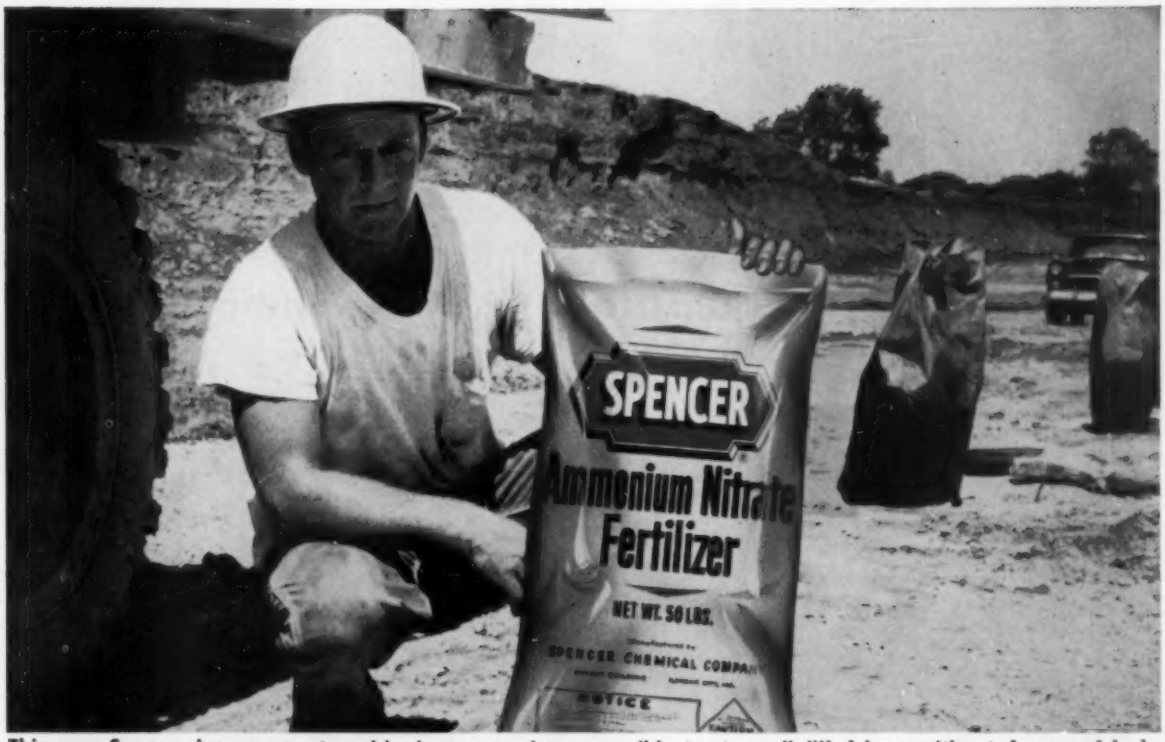
The only time I am really discouraged is when I sit down at the end of the month and try to decide what can be paid and the priority of payment. Something or someone is usually slighted, and my dues have received far less consideration than I should like to have given them. I just hope that I won't be forced to make some of these same decisions next year.

Again I should like to thank you for your letter of the 23rd. I feel that this letter warrants a personal answer to you along with some sort of an explanation as to why I have been delinquent. I sincerely assure you that I consider it a privilege and a pleasure to be numbered in a Society which takes such individual interest in its members.

Small Operator

I know that things have been particularly hard for miners big and

(Continued on page 1035)



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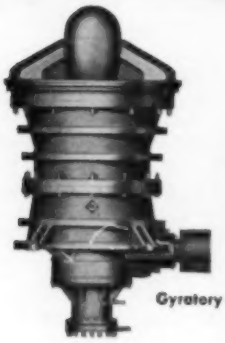
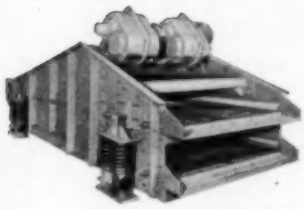
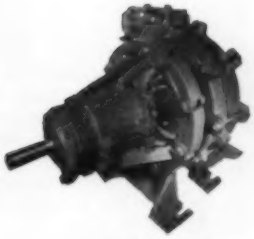


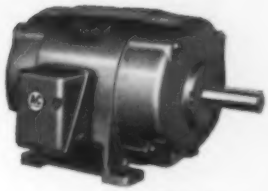
Gyratory Crushers



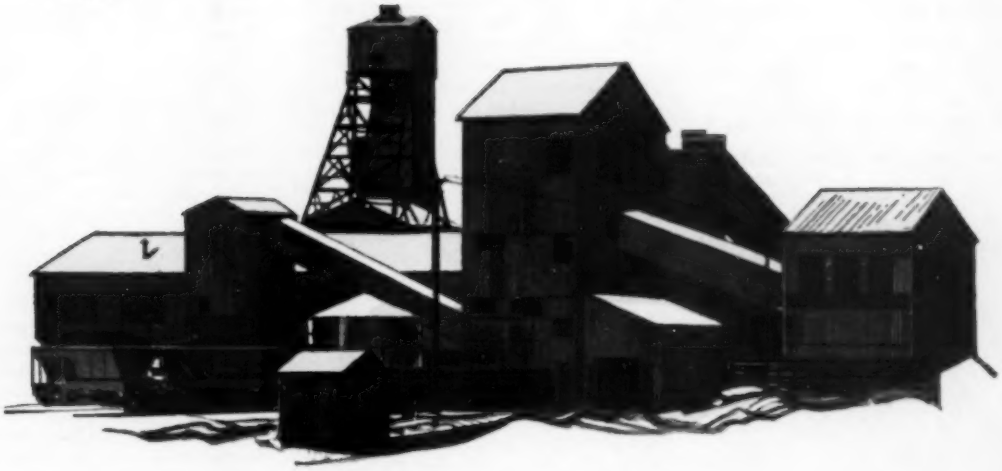
Screens



Rubber-Lined Pumps



Motors



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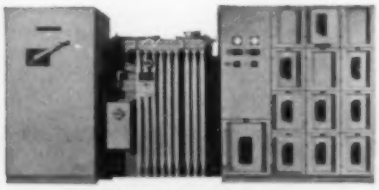

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Surface Chemistry: Theory and Applications, by J. J. Bickerman, second edition, *Academic Press,* 111 Fifth Ave., New York 3, N. Y., 501 pp., $15, 1958.—Contains substantial data on electric surface phenomena, particularly electrokinetic theory and measurement. Many sections have been rewritten, incorporating new developments within the past ten years and re-evaluating material preceding this period. The author treats surface chemistry as a part of physical chemistry. • • •

Manual of ASTM Standards on Refractory Materials, eighth edition, *American Soc. for Testing Materials,* 1916 Race St., Philadelphia 3, Pa., 397 pp. $5.50, 1957.—Brings together all of the ASTM standards and tentative specifications, classifications, methods of testing, and definitions pertaining to refractories. Also includes suggested procedure for calculating heat losses, petrographic techniques, and industrial surveys of service conditions of refractories. • • •

Engineering College Research Review, edited by Renato Contini, 1957-1959 edition, *Engineering College Research Council,* University Heights, New York 53, N. Y., 440 pp., $2, 1958.—An exhaustive analysis and location guide for engineering and associated science research activities. Valuable for use in college and industry libraries, for placement of research contracts, or for individual research workers. The institution, the research administration personnel, their policies or limitations, courses, conferences, and projects are listed by title. Special features include a history of the ECRC with a statement of their research policy, and a listing of member institutions. • • •

Agricola on Metals, by Bern Dibner, *Burndy Library,* Norwalk, Conn., 128 pp., $2.50, 1958.—Distilled from *De Re Metallica,* written in Latin in 1556 by Georgius Agricola, and translated into English by Herbert Hoover and his wife in 1912, this book also comments on the scholarship of the translators. This historic textbook on mining and metallurgical engineering in the 16th century shows the highly developed industrial culture that is the heritage of modern technology. Many of the features of mass production are foreshadowed in the early use of power-operated machinery; the division of labor into sorters, washers, smelters, and other specialists; the complex hierarchy of administration; and the unusual concern for the miners' health and safety. • • •

Low Grade Ores, A Survey of American Research Methods, published by The European Productivity Agency, *Organization for European Economic Cooperation,* Publications Office, 1346 Connecticut Ave. N.W., Washington 6, D. C., 160 pp., $3, 1958.—The report of representatives of nine European countries on a mission in the U. S. and Canada to study the latest methods of chemical and physical research employed in ore beneficiation and concentration. Special attention was paid to the relationships of the organizations studied, their research facilities, and financial backing. • • •

Technical Advances in Milling and Process Metallurgy in Canada During 1957, Information Circular IC 103, by L. E. Djingheuzian, *Dept. of Mines and Technical Surveys,* Mines Branch, Ottawa, Ont., Canada, 8 pp., 1958.—Article reprinted from *Canadian Mining Journal,* February 1958, shows the intensified research into improving methods of recovery and processing of metals with the hope of offsetting falling base metal prices.

The Leaching of Manganese from Pyrolusite Ore by Pyrite, Research Report No. R 3, by G. Thomas and B. J. P. Whalley, Publications Distribution Office, *Dept. of Mines and Technical Surveys,* Mines Branch, Ottawa, Ont., Canada, 25¢, 1958.—Address requests for copies to: Publications Distribution Office, Mines Branch, and include postal or express money order, made payable to the Receiver General of Canada.

The Industrial Minerals of Newfoundland, Report No. 855, by G. F. Carr, Industrial Minerals Div., Publications Distribution Office, *Dept. of Mines and Technical Surveys,* Mines Branch, Ottawa, Ont., Canada, $2, 1958.—Requests for copies should be accompanied by postal or express money order, made payable to the Receiver General of Canada.

Zinc in Canada with Comments on World Conditions, Memorandum Series No. 137, by R. E. Neelands and D. E. Fraser, Publications Distribution Office, *Dept. of Mines and Technical Surveys,* Mines Branch, Ottawa, Ont., Canada, 50¢, 1958.—For copies send postal or express money order payable to Receiver General of Canada.

ASTM 1957 Proceedings, Vol. 57, *American Society for Testing Materials,* 1916 Race St., Philadelphia 3, Pa., 1430 pp., $12, 1958.—This volume includes the summary of proceedings of the ASTM 60th annual meeting and the Philadelphia spring meeting, the annual president's address, 66 reports of technical committees, special sessions and papers, and an index of all papers published by the society in 1957. • • •

Coal Mines in Canada, Mineral Resources Operators List No. 4, Publications Distribution Office, *Dept. of Mines and Technical Surveys,* Mines Branch, Ottawa, Ont., Canada, 25¢, 1958.—Postal or express money order, made payable to Receiver General of Canada, must accompany copy request.

Geological Map Symbols, Data Sheets Nos. 1-3, *American Geological Institute,* 2101 Constitution Ave., Washington 25, D. C., special price to educational institutions of 15¢ per set of 3 in quantities of 10 sets or more; set of 3, 25¢. • • •

Availability of Publications and Other Data of the U. S. Geological Survey, Data Sheet No. 4, *American Geological Institute,* 2101 Constitution Ave., Washington 25, D. C., 10¢. • • •

Geologic Column and Scale of Time, Data Sheet No. 5, *American Geological Institute,* 2101 Constitution Ave., Washington 25, D. C., 10¢. • • •

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Gmelins Handbuch der Anorganischen Chemie, System Nr. 28: Calcium, eighth edition, Verlag Chemie, Weinheim/Bergstrasse, Germany, 656 pp., 219DM ($52.56), 1957.—A compilation of technical data on the respective elements and their compounds. This calcium volume covers calcium compounds with hydrogen, oxygen, nitrogen, fluorine, chloride, bromine, iodine, and sulfur. • • •

Gmelins Handbuch der Anorganischen Chemie, System Nr. 60: Kupfer, eighth edition, Verlag Chemie, Weinheim/Bergstrasse, Germany, 624 pp., 349DM ($83.76), 1958.—This volume covers copper compounds with the same eight elements in the calcium volume, plus selenium and tellurium. For each compound, data are given for structure, chemical and physical properties, thermodynamic characteristics, and other pertinent information, with graphs and tables. • • •

Television in Science and Industry, by V. K. Zworykin and others, *John Wiley & Sons Inc.*, 300 pp., $10, 1958.—A detailed description of television equipment plus an introduction showing the application of television to industry, medicine, and other purposes. • • •

Managing Geographically Decentralized Companies, by George A. Smith, Jr., *Harvard Business School*, Div. of Research, Soldiers Field, Boston 63, Mass., 185 pp., $3.50, 1958.—An analysis of the clinical histories of decentralized firms and of their organizational problems and experience. • • •

Man, Metals and Modern Magic, by J. Gordon Parr, published jointly by the *American Society for Metals*, 7301 Euclid Ave., Cleveland 3, Ohio, and the *Iowa State College Press*, Ames, Iowa, 238 pp., $2.95, 1958.—A history of the role that metals have played in the development of civilization, from 6000 B.C. to the present. • • •

Differential Thermal Analysis, by W. J. Smothers and Yao Chiang, *Chemical Publishing Co. Inc.*, 212 Fifth Ave., New York 10, N. Y., 444 pp., $16, 1958.—The origins of the method, the equipment needed, the

(Continued on page 1036)

LETTERS

Continued from page 1030

small during this year and doubly appreciate your decision to pay your dues at this time. There are some indications that the economy is on the upswing again.

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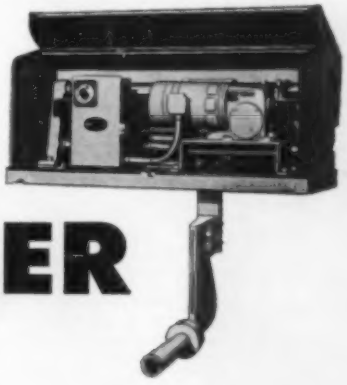

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BOOKS

Continued from page 1035

factors involved, and selected applications of quantitative differential thermal analysis are covered. • • •

STATE PUBLICATIONS

Barite Deposits in Montana, by Victor C. DeMunck and Walter C. Ackerman, Information Circular 22, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., 30 pp., 3 plates, gratis, 1958.

Potosi Tungsten District in Madison County, Montana, by Theodore H. Eyde, Information Circular 21, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., gratis, 1958.

Geology and Mineral Resources of Elko County, Nevada, by Arthur E. Granger, Mendell M. Bell, George C. Simmons, and Florence Lee, prepared cooperatively by the USGS and *University of Nevada*, Reno, Nev., 216 pp., 19 maps, 23 figs., 8 tabs., $2.50 (plus 10¢ postage and handling), 1957.

Geological Quadrangle Maps of New Hampshire: Bellows Falls, Franconia, Keene-Brattleboro, Littleton, Lovewell Mountain, Mascoma, Monadnock, Mt. Chocorua, Mt. Cube, Mt. Pawtuckaway, Mt. Washington, Percy, Plymouth, Sunapee, Wolfeboro; *New Hampshire State Planning & Development Commission*, State Office Bldg., Concord, N. H., 50¢ (20% discount for 10 or more of each map), make check payable to State of New Hampshire.

Sands of the Merrimack Valley, by Lawrence Goldthwait, Preliminary Report XVI, *New Hampshire Planning & Development Commission*, State Office Bldg., Concord, N. H., 19 pp., 50¢ (make check payable to State of New Hampshire), 1957.

The Geology of New Hampshire, Vol. III, Minerals and Mines, by T. R. Meyers and Glenn W. Stewart, *New Hampshire State Planning & Development Commission*, State Office Bldg., Concord, N. H., 107 pp., map, $1.50 (make check payable to State of New Hampshire), 1956.

Topographic Map of New Hampshire, *New Hampshire Planning & Development Commission*, State Office Bldg., Concord, N. H., 51x39 in., 3 colors, 1 in. equals 4 mi, $1.00 (make check payable to State of New Hampshire).

Geologic Map of New Jersey, No. 40, *State Bureau of Geology and Topography*, State Geologist, New Jersey Dept. of Conservation and Economic Development, 520 East State St., Trenton, N. J., 27x48 in., $2.00 (make check payable to Treasurer, State of New Jersey).

Surface Formations, Valley of the Passaic, map, *State Bureau of Geology and Topography*, State Geologist, New Jersey Dept. of Conservation and Economic Development, 520 E. State St., Trenton 25, N. J., 27x38 in., 50¢ (make check payable to Treasurer, State of New Jersey).

CANADIAN PUBLICATIONS

Aeromagnetic Survey 1954, Sherridon Area, Mines Branch, *Dept. of Mines & Natural Resources*, Winnipeg, Manitoba, Canada, scale 1 in. to ½ mile, $5.

Geology of the Winnipeg River Area, Publication 56-1, by J. F. Davies, Mines Branch, *Dept. of Mines & Natural Resources*, Winnipeg, Manitoba, Canada, $1, 1956.

Isopach and structure contour map of the Mississippian System of southwestern Manitoba, Stratigraphic Map No. 4, compiled by H. M. Zaborniak, *Dept. of Mines and Natural Resources*, Mines Branch, Winnipeg, Manitoba, Canada, $2, 1957.

Daly Field-Structure contour map on the First Crinoidal Zone of the Lodgepole Formation, Stratigraphic Map No. 7, compiled by O. J. Fleming, *Dept. of Mines and Natural Resources*, Mines Branch, Winnipeg, Manitoba, Canada, $2, 1957.

Structure contour map of Upper Virden Member, Lodgepole Formation, Stratigraphic Map No. 8, compiled by O. J. Fleming, *Dept. of Mines and Natural Resources*, Mines Branch, Winnipeg, Manitoba, Canada, $2, 1957.

Structure contour map, top of Precambrian, Stratigraphic Map No. 10, compiled by O. J. Fleming, *Dept. of Mines and Natural Resources*, Mines Branch, Winnipeg, Manitoba, Canada, $2, 1957.

Structure contour and isopach map of Winnipeg Formation, Stratigraphic Map No. 11, compiled by O. J. Fleming, *Dept. of Mines and Natural Resources*, Mines Branch, Winnipeg, Manitoba, Canada, $2, 1957.

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Structure contour and isopach map of Stony Mountain Formation, Stratigraphic Map No. 13, compiled by O. J. Fleming, *Dept. of Mines and Natural Resources*, Mines Branch, Winnipeg, Man., Canada, $2, 1957.

Structure contour and isopach map of sand zone, Ashville Formation, Stratigraphic Map No. 14, compiled by O. J. Fleming, *Dept. of Mines and Natural Resources*, Mines Branch, Winnipeg, Man., Canada, $2, 1957.

Annual Report of the Dept. of Lands and Mines, *Mines Branch*, c/o Custodian of Maps, P.O. Box 758, Fredericton, New Brunswick, Canada, gratis.

Salt, Information Circular 57-1, by J. B. Hamilton, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, 1957.

Limestone, Information Circular 57-2, by J. B. Hamilton, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, gratis, 1957.

Coal, Information Circular 57-3, by J. B. Hamilton, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, gratis, 1957.

Map of Upper Paris Pabineau and Little Rivers, Geology P-7, by A. L. McAllister and J. C. Smith, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, gratis, 1957.

Map of Nepisiguit River—Ninemile and Nepisiguit Brooks, Geology P-8, by J. C. Smith and A. L. McAllister, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, 1957.

Map of Fosterville, York County, by W. M. Tupper, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, 1957.

Map of Canterbury, (west half) York County, by J. M. Patterson, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, 1957.

Map of Middle and Little Rivers, Geology P-6, by R. A. Jones and J. C. Smith, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, 1958.

Map of Canterbury (east half), York County, by J. M. Patterson, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, 1958.

Exploration in New Brunswick, 1932-1957, Reproduction, by C. P. Jenney, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, 1957.

Occurrence and Treatment of Woodstock Manganese Ores, Reproduction, by G. C. Monture, *Dept. of Lands and Mines*, Geological Div., Mines Branch, Fredericton, N.B., Canada, 1957.

Geological Map of the Maritimes, Map 910A, *Geological Survey of Canada*, distributed by the Mines Branch, College Hill, Fredericton, N.B., Canada.

Bathurst-Newcastle Area, Map 1-1957, by C. H. Smith, *Geological Survey of Canada*, distributed by the Mines Branch, College Hill, Fredericton, N.B., Canada, 1957.

Burtis Corner (west half) York County, Map 7-1957, by W. H. Poole, *Geological Survey of Canada*, distributed by the Mines Branch, College Hill, Fredericton, N.B., Canada, 1957.

Geology of Oderin and Neighboring Islands, Placentia Bay, Report No. 9, by D. H. Williamson, *Geological Survey of Newfoundland*, Dept. of Mines and Resources, St. John's, Nfld., Canada, 50¢, 1956.

Port Saunders—Castor River Area, west coast, Report No. 10, *Geological Survey of Newfoundland*, Dept of Mines and Resources, St. John's, Nfld., Canada, 50¢, 1957.

Geology of the Lower Gander River Ultrabasic Belt, Report No. 11, *Geological Survey of Newfoundland*, Dept. of Mines and Resources, St. John's, Nfld., Canada, 50¢, 1957.

Rocks and Minerals of Newfoundland, Information Circular 8, by D. M. Baird, *Geological Survey of Newfoundland*, Dept of Mines and Resources, St. John's, Nfld., Canada, 50¢, 1955.

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Forgeability of Steels, Information Circular IC 102, by G. P. Contractor and W. A. Morgan, *Publications Distribution Office*, Mines Branch, Dept. of Mines and Technical Surveys, Ottawa, Canada, 25¢, (make postal money order payable to the Receiver General of Canada), 1958.

A Chemical Study of the Peats of Quebec, Preliminary Report No. 350, by J. Risi, C. E. Brunette, R. Cloutier, and H. Girard, *Dept. of Mines*, Laboratories Branch, Quebec, Que., Canada, 36 pp., 7 figs., 1958.

U. S. GOVERNMENT PUBLICATIONS

55M Suggestions To Authors of the Reports of the U. S. Geological Survey, Fifth Edition, Superintendent of Documents, Government Printing Office, Washington 25, D.C., Catalog No. I 19.2:Su 3/5/958, 255 pp., cloth $1.75, 1958.

56M Bibliography of North American Geology, 1955, Superintendent of Documents, Government Printing Office, Washington 25, D.C., Catalog No. I 19.3:1065, 511 pp., $1.50, 1958.

U. S. Bureau of Mines

The Boron Industry in Turkey, Mineral Trade Notes, Special Supplement No. 53, Vol. 46, No. 5, by Thomas G. Murdock, Publications Distribution Section, Mailing List, U. S. Bureau of Mines, Washington 25, D.C.

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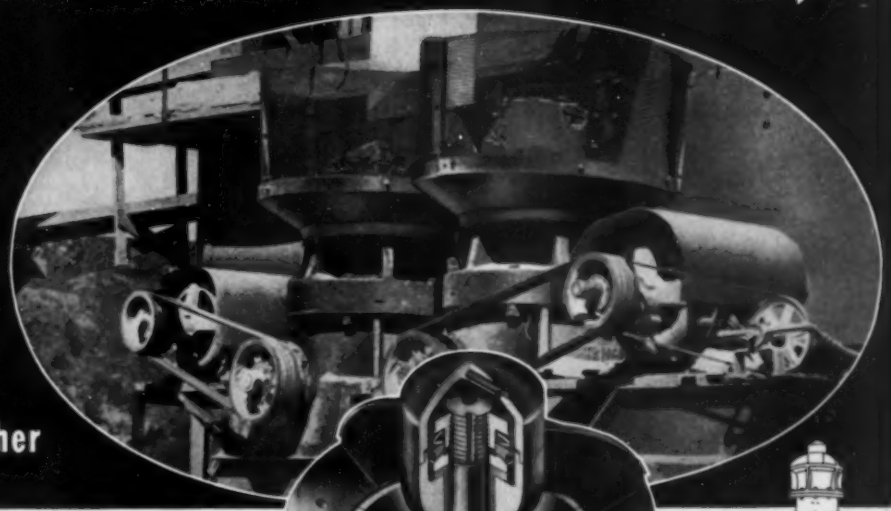

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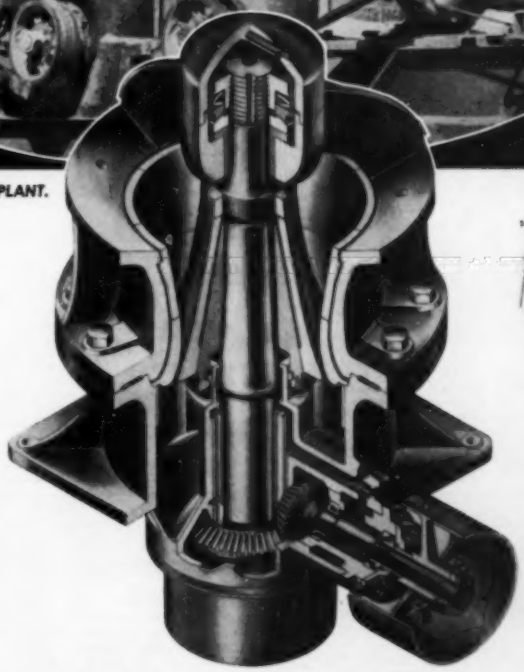

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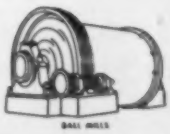

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ROTARY DRYERS

ABSTRACTS

In This Issue: *The following abstracts of papers in this issue are reproduced for the convenience of members who wish to maintain a reference card file and for the use of librarians and abstracting services. At the end of each abstract is given the proper permanent reference to the paper.*

Fluosolids Roasting of Yanahara Sulfides, by *H. Kurushima and R. M. Foley*—The treatment of Yanahara pyrrhotite has been a profitable venture for Dowa Mining Co. In addition to the monetary return obtained from the sale of copper, sulfuric acid, and iron ore, mining costs on the pyrite have been reduced. By mining both pyrite and pyrrhotite the overall pyrite yield from the mine has increased by more than 10 pct. Prospecting has also simplified and has incidentally led to a new discovery which may total 20 million tons. **Ref.: MINING ENGINEERING, October 1958, pp. 1057-1061.**

Exploration Extends Magma's Future, by *Russell Webster*—Located on the northwestern boundary of a mineral district in Arizona that includes such past and present major copper producers as Inspiration and Miami Copper Co. at Miami, the Old Dominion Mine in Globe, the Ray Mine in Ray, and to the south the new San Manuel Mine near Tucson, the Magma Mine is unique in that it has maintained production for over 40 years.

The Magma Copper Co. has in its east replacement ore body a potential that as recently as six years ago was little known. Located about 2,000 feet east of the vein area in the central portion of the mine, the east replacement bed can be considered as a separate mining unit with exploration, development and mining problems that are peculiar to this area alone. If these problems can be satisfactorily solved and if a favorable national economic situation exists, the east replacement ore body will give additional life to the long productive Magma Mine. **Ref.: MINING ENGINEERING, October 1958, pp. 1062-1065.**

High Pay For Top Executives in Nonferrous Metals Industry, by *S. Robinson Brainard*—Top executive compensation in the nonferrous field was well above the major industrial average in 1957. And it rose further last year even though sales and profits declined sharply. **Ref.: MINING ENGINEERING, October 1958, pp. 1066-1067.**

Ore Grade Control—Jackpile Mine by *Robert B. Schlosser*—Grade of uranium ore is controlled by sampling blast holes. An accurate grade estimate of each railroad car of ore is then obtained through use of a specially devised ore grade control instrument. **Ref.: MINING ENGINEERING, October 1958, pp. 1068-1069.**

Ore Control and Mining at the Lucky Mc Mine, Wyoming, by *K. G. Wallace*—The Lucky Mc mine is located in the Gas Hills Uranium District of central Wyoming, about 50 miles east of the city of Riverton. The Gas Hills District (embracing about 200 square miles) in the four and one half years since the initial uranium discovery was made, has become the hub of one of the most important uranium-producing areas in the country—the central Wyoming uranium region of some 10,000 square miles.

It became apparent during 1955 that substantial ore reserves occurred on the Lucky Mc property, and a mill to treat the ores might therefore be justified. At this point Lucky Mc invited Utah Construction Co. to participate in the venture.

So far the following has been accomplished: exploration of the Lucky Mc property and development of a sufficient tonnage of ore to justify a mill proposal; negotiation of a milling contract with the Atomic Energy Commission; securing financing for the mill and accessory facilities; and the design and construction of the mill, camp, and mine plant.

Mine problems encountered and methods of solution and operation are covered in detail.

With the present mine organization and equipment it is planned to strip over 5,000,000 cubic yards this year and mine sufficient ore to build up sizeable ore stockpiles in addition to supplying the current ore requirements of the mill. **Ref. MINING ENGINEERING, October 1958, pp. 1070-1073.**

Blending Control at Cord Mine, by *S. E. Craig*—Jen Inc., operator of the Cord mine, has a contract with a milling company that provides a small bonus for proper grading and preparation of uranium ores shipped. To obtain maximum returns on this contract very close grading is required, with settlements made on individual lots, which vary from 250 to 300 tons.

Another feature of the contract, and one that is rather unique in this country, is that the ore is sold over truck scales at the mine.

The crusher, in operation only a short time, aside from its value for grade control, appears able to pay its way in more accurate samples and in reducing moisture in ore shipped by ½ or ¾ pct. Calculating the larger reduction on a 10,000-ton monthly shipment, this amounts to 75 tons of ore per month. If this ore has a value of $50 per ton this saving amounts of $3750 per month or 37¢ per ton of ore crushed. It is estimated that crushing expense will be 15¢ per ton.

The value of properly marketing ore must not be underestimated. A superintendent will spend a great deal of time and effort to lower his powder cost a dime a ton or any other cost a few cents; so it is well that we look to grading and blending—there may be two-bits there. **Ref.: MINING ENGINEERING, October 1958, p. 1074.**

Good Practice in Uranium Ore Sampling, by *Gilman C. Ritter*—Adequate control requires good sampling. Data are given as a guide to the four major steps in general practice—moisture sampling, size reduction, sample cutting, and preparation.

Errors attributable to the human element include poor moisture sampling, failure to clean sampling equipment between samples, and improper use of laboratory equipment. Failure to thoroughly mix the final mechanical sample before sample preparation begins and insufficient blending time prior to laboratory splits also contribute to inaccuracies. These inconsistencies can only be corrected through the use of thoroughly trained, conscientious personnel. **Ref.: MINING ENGINEERING, October 1958, p. 1075.**

DSM Screens in a Heavy-Media Cyclone Plant, by *W. R. Van Slyke, James Stukel, and Leon D. Keller*—The use of two 4-ft wide DSM screens in a float drain capacity in a Heavy Media Cyclone Plant, materially reduced the quantity of media being sent to the magnetic separator cleaning circuit.

Capacity at fine size screening is high, and wear does not appear to be excessive in this application. Future plant design incorporating these units and other flowsheet modifications made possible by the use of the DSM screen should show a marked reduction in capital cost. **Ref.: MINING ENGINEERING, October 1958, pp. 1076-1078.**

Jamaican Bauxite in the West Indies Economy, by *Smith Bracewell*—First evidence of bauxite in Jamaica resulted from an analysis of a soil sample collected at Bull Savannah in 1938 during a systematic local investigation of the island's soil types.

Close to large markets and processing some of the world's largest bauxite deposits, Jamaica expects stepped-up mining will bring production of 6 million tons annually by 1959.

The industry is therefore an important asset, not only to Jamaica itself, but to the West Indian Federation as a whole. Like the oil industry of Trinidad, it should serve to strengthen the Federation and to ensure its economic stability and independence. **Ref.: MINING ENGINEERING, October 1958, pp. 1079-1080.**

Application of Electrostatics to Potash Beneficiation, by *I. M. LeBaron and W. C. Knopf* (TP 4761H)—Development of a process for the dry beneficiation of potash minerals would result in many advantages over present methods. In the Carlsbad area potash is dry mined and then wet concentrated.

Wet concentration involves recirculation of saturated brines with the resultant difficulties involving disposal of this brine and the inherent losses in recovery through solution of the KCl. International Minerals and Chemical Corporation has been working on the development of a dry process for some time. This paper presents the data obtained up to this time.

Potash ores available in this country are largely mixtures of halite and sylvite contaminated with slimes and often many sulfate and magnesium minerals. Electrostatic concentration of KCl when the contaminating minerals are in low percentage has been accomplished. The continuous production of better than 60% K_2O concentrate from high potassium sulfate ores has not been demonstrated at the present time. **Ref.: (MINING ENGINEERING, October 1958); AIME Trans., 1958, vol. 211, pp. 1081-1083.**

Application of Electrostatics to Concentration of Coarse Pebble Phosphate, by *E. Northcott and F. N. Oberg* (TP 4762H)—By electrostatic separation, coarse Florida pebble phosphate, too low-grade to find a ready market, can be upgraded to a satisfactory saleable product. Pebble running from 60 pct bone phosphate of lime may be upgraded to 73 to 77 pct BPL depending on the mineralogical structure of the pebble and the nature of the silica impurity. **Ref.: (MINING ENGINEERING, October 1958); AIME Trans., 1958, vol. 211, pp. 1084-1086.**

Application of Electrostatics to Feldspar Beneficiation, by *E. Northcott and I. M. LeBaron* (TP 4763H)—Recent technological improvements in the beneficiation of feldspar by the LeBaron-Lawver electrostatic process are reported. Batch and sub-pilot plant tests were performed with satisfactory results. Included are data on equipment, material flow and process. **Ref.: (MINING ENGINEERING, October 1958); AIME Trans., 1958, vol. 211, pp. 1087-1093.**

The Geiger Counter as a Control Tool in Potassium-Bearing Ores, by *W. C. Knopf and Gene Samsel* (TP 4764H)—Thousands of measurements have been recorded on a laboratory scale and in pilot plant processing operations comparing chemical assays on potassium-bearing ores with those using radiation techniques. These results show that the radiation technique can be made readily adaptable as a control tool. Variables that affect radiation measurements are discussed. **Ref.: (MINING ENGINEERING, October 1958); AIME Trans., 1958, vol. 211, pp. 1094-1096.**

SME Meeting Papers: *The following abstracts of papers presented at SME meetings are given for your information. Copies of these papers are available only if followed by a preprint order number. These preprints are obtained on a coupon basis. The coupon books may be purchased from SME headquarters for $5.00 a book (10 coupons) for members of AIME or $10.00 a book for nonmembers. Each coupon, properly filled out, entitles the purchaser to one preprint. Mail completed coupons to Preprints, Society of Mining Engineers, 29 W. 39th St., New York 18, N.Y.*

A Petrographic Investigation of the Causes of Degradation of Sized Coal, by *R. C. Neavel*—One of the most important specifications to be met by any producer of coal is that of delivering size—minimum as well as maximum—tailored to specific applications.

An investigation aimed at determining the cause of breakage in transit was undertaken. Two basic facts about coal and coal seams led to the employment of petrographic techniques in this investigation. First, all coal seams consist of accumulations of diverse organic and inorganic constituents; and second, most coal breakage, either desirable or undesirable, can be attributed to the inherent weakness of some of these constituents or to poor adhesion between certain constituents.

The investigation conducted by the Indiana Geological Survey at the request of one producer led to certain conclusions. The degradation that takes place after mining and preparation of coal (principally 2 in. sizes) from one particular mine and presumably from others as well is caused by an unknown process [temperature variations (?), desiccation (?)] affecting thin clay laminae in the coal. Shipments containing concentrations of coal with many clay laminae can be expected to degrade when subjected to the causative process. Further work on the ultimate cause may indicate some method of treating the coal or preventing the ultimate cause from affecting the shipments.

Possibly because of the tendency of the high-clay coal to break into elongate slabs, these extremely clayey portions are concentrated in the larger sizes. As only one fourth of the total mined coal contains concentrations of clay laminae, it should be possible to exercise care in blending the coal and thus prevent concentrating high-clay coal in any one shipment. The problem of severe degradation thus can be essentially eliminated. *AIME-ASME Joint Solid Fuels Conference, September 1958, 58SF3.*

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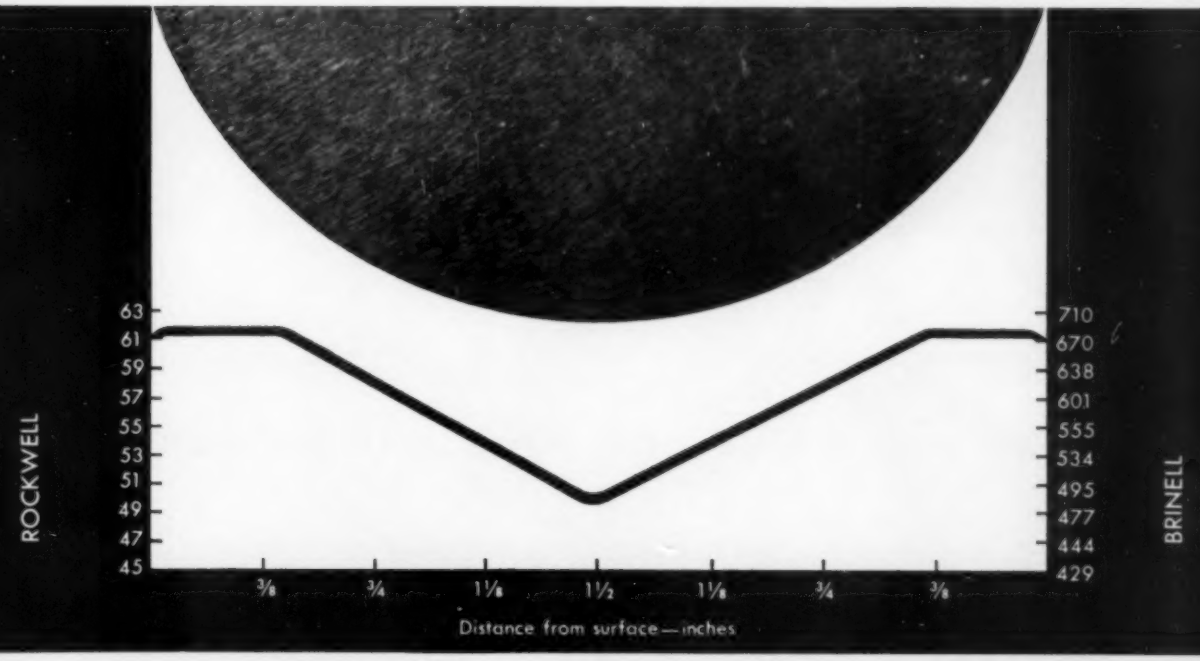

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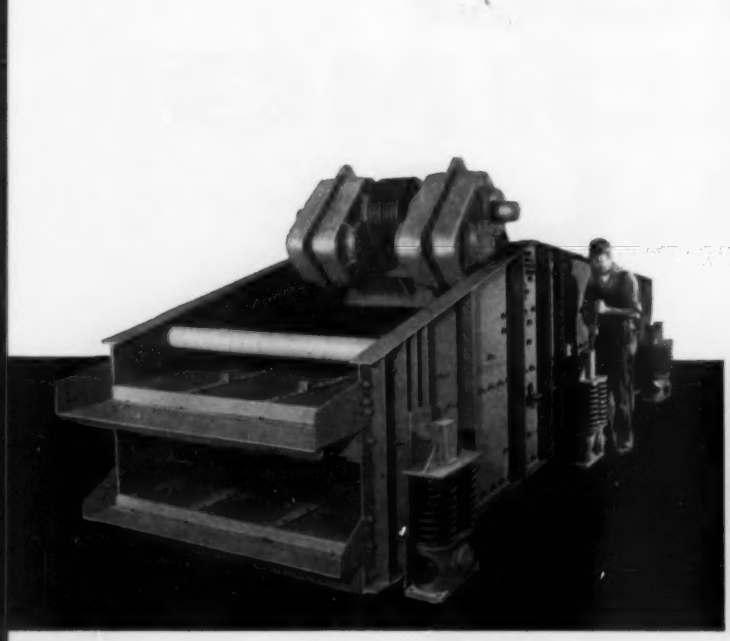

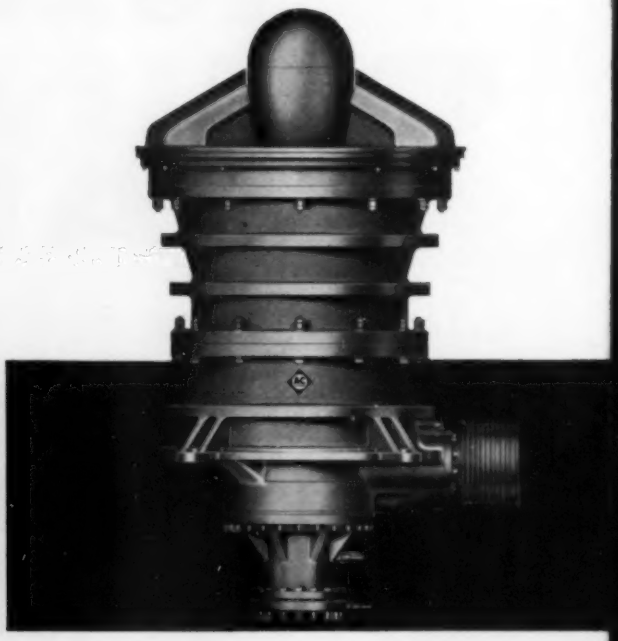

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Practically every type of material mined or quarried is being processed by "Coordineered" equipment from Allis-Chalmers. Coordineering means that product departments work together on a single problem before equipment recommendations are made. Product experts make sure equipment is properly engineered for your specific job — that new units are integrated with both new and existing equipment.

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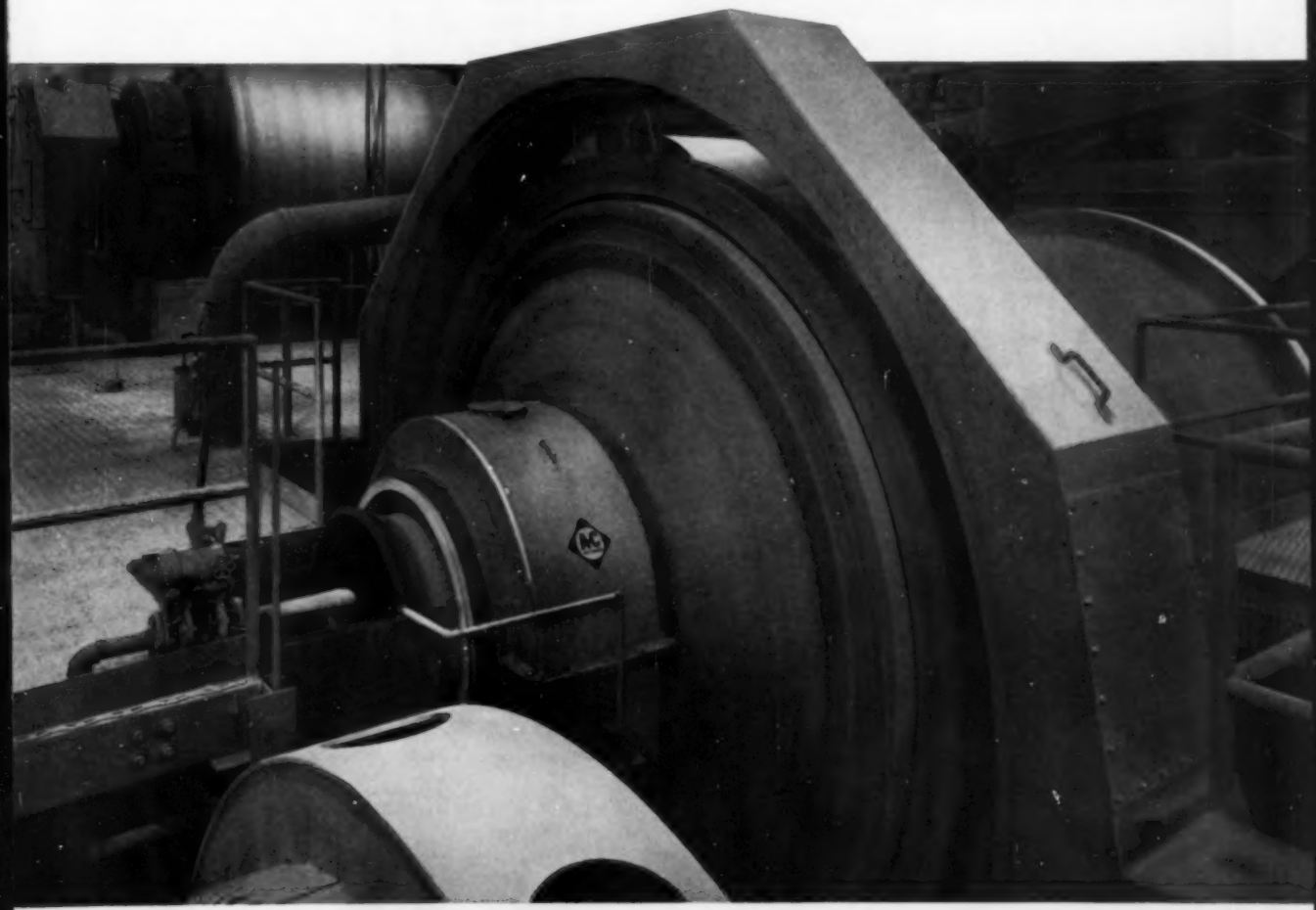
Make use of this valuable engineering in the early stages of your expansion or modernization program. An Allis-Chalmers technical team will gladly confer with you or your consultants. Your nearby Allis-Chalmers representative will arrange details. Get in touch with him, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.



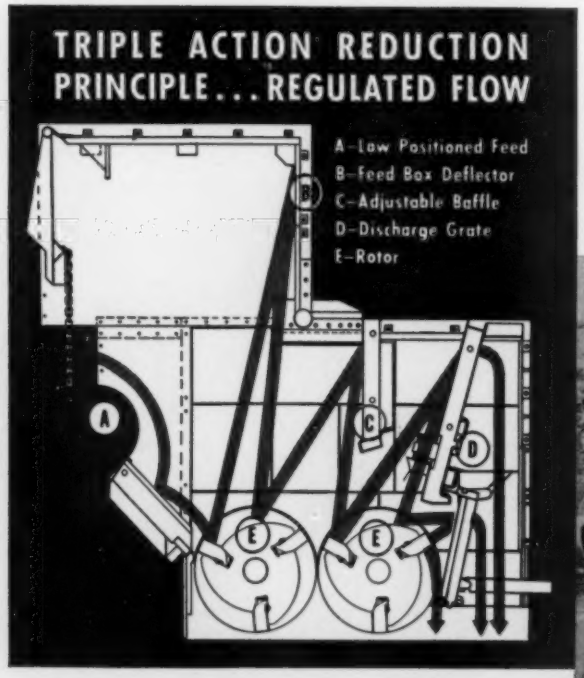
ALLIS-CHALMERS

HIGHER reduction ratios

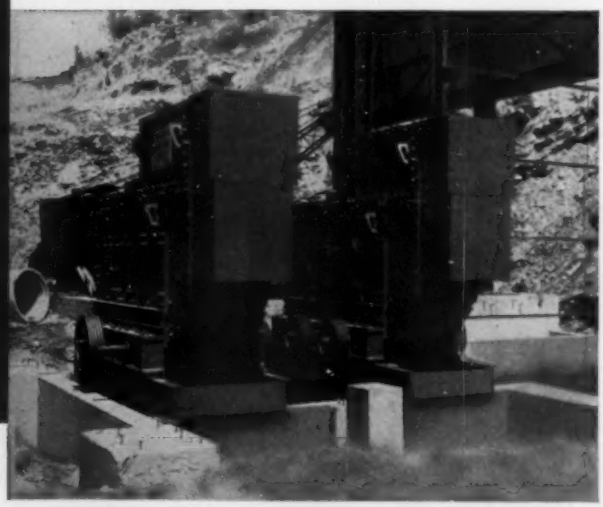
THE KENNEDY CUBER SENIOR

uses a new, proven concept in impact breaking

...for stationary or portable use



This heavy duty impact breaker is designed for primary and secondary breaking of non-abrasive stone and similar materials in a single unit. It is a dual rotor, up-running breaker featuring a multi-stage, triple action reduction principle and regulated flow.



Two Cuber Seniors in service at a Pennsylvania cement plant, operating as secondaries in a closed circuit, producing raw mill feed. The Cuber Senior can also be used as a portable unit.

THE KENNEDY CUBER SENIOR

- delivers high capacities of cubical material at lower cost —with lower horsepower per ton
- handles quarry rock that will pass its feed opening
- can be operated in a closed circuit to produce 100% passing 1" with many types of rock
- has a low positioned feed device that lowers feed height for maximum rock penetration into impact zone
- can be used as a stationary or a portable unit
- can accommodate differing characteristics of various rock types with its adjustable baffle and variable speed

We invite you to send for Bulletin D-1003 describing the Cuber Senior, and to have your material tested by KVS with no obligation to you.

KENNEDY VAN SAUN

MANUFACTURING & ENGINEERING CORPORATION

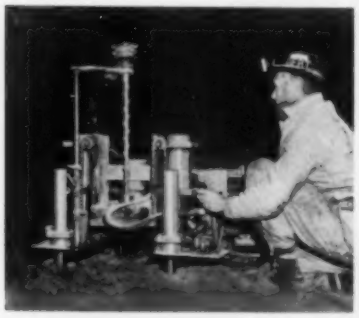
405 Park Avenue, New York 22, N. Y. • Factory, Danville, Pa.

MANUFACTURERS NEWS

NEWS / EQUIPMENT / CATALOGS

Hydraulic Roof Bolter

Schroeder Bros. Corp. offers a hydraulic roof bolting machine called the Roofcat. Unit trams 175 fpm, weighs 2700 lb, and feed length



of the auger sections runs from 28 to 44 in. A coal drill can be operated from the Roofcat's hydraulic circuit, which is protected by a micronic return line filter. **Circle No. 1.**

Tractor-Shovel

Frank G. Hough Co.'s new model H-70 replaces the model HH Payloader and features four-wheel drive and 7000 lb carrying capacity. The new loader boasts more power, better traction, greater protection against dust, complete power-shift transmission, other refinements. **Circle No. 2.**

Truck Crane

Stanco Mfgs. & Sales Inc. offers a one-man operated truck crane with lifting capacity up to 6000 lb. Known as the Hiab 170, the crane requires only 15 in. of space between cab and truck bed. Unit is useful in large tire handling, engine replacement, moving pipe and crated materials. **Circle No. 3.**

Cold Rolled Steels

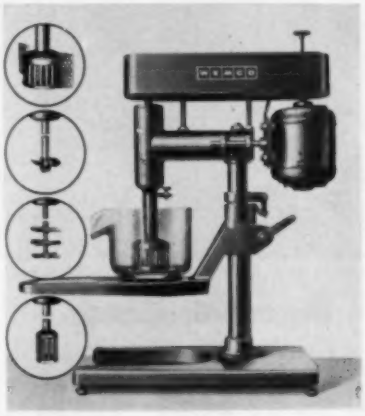
Fatigue-resistant 1½ and 2-in. cold rolled alloy extension drill steel has been introduced by *Atlas Copco.* New Sandvik Coromant steels are rope-threaded—two threads to the inch—for easy coupling and uncoupling. Rod shank adapters and rope-threaded bits are available to match the new steel. **Circle No. 4.**

Mobile Magnetometer Surveys

Heinrichs Geoexploration Co. offers a mobile magnetometer service employing a truck-mounted detector servo-oriented to give maximum intensity readings on a repeating chart scale. Geoex will supply crew, equipment, magnetic contour maps where practical, and interpretive reports. **Circle No. 5.**

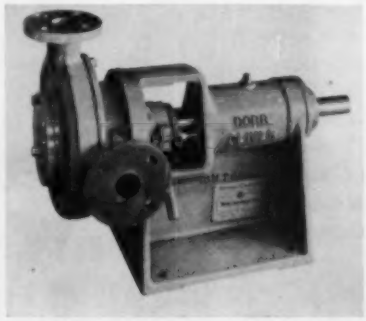
Lab Cell

Test work in flotation, agitation, and attrition can now be done with a single lab unit by *Western Machinery Co.* Mineral Master, a modernized Fagergren unit, features aluminum construction and stainless steel impellers. **Circle No. 6.**



Centrifugal Pumps

Dorr-Oliver Inc. offers three new pumps based on type L design and featuring interchangeability of parts. New LH unit operates at up to 3500 rpm for stepped up capacity and head range. LR (shown) has reverse inlet, handles high solids slurries and volatile liquids. LX is designed for corrosive service and can be removed without disturbing connecting piping when maintenance work is due. **Circle No. 7.**



High-Velocity Primer

American Cyanamid Co. has developed its new CX-311 primer for optimum detonation of low cost blasting agents. The 1½-lb cartridge is 2½ in. diam x 6 in. and is fitted with tubular sleeve for quick Primacord attachment. **Circle No. 8.**

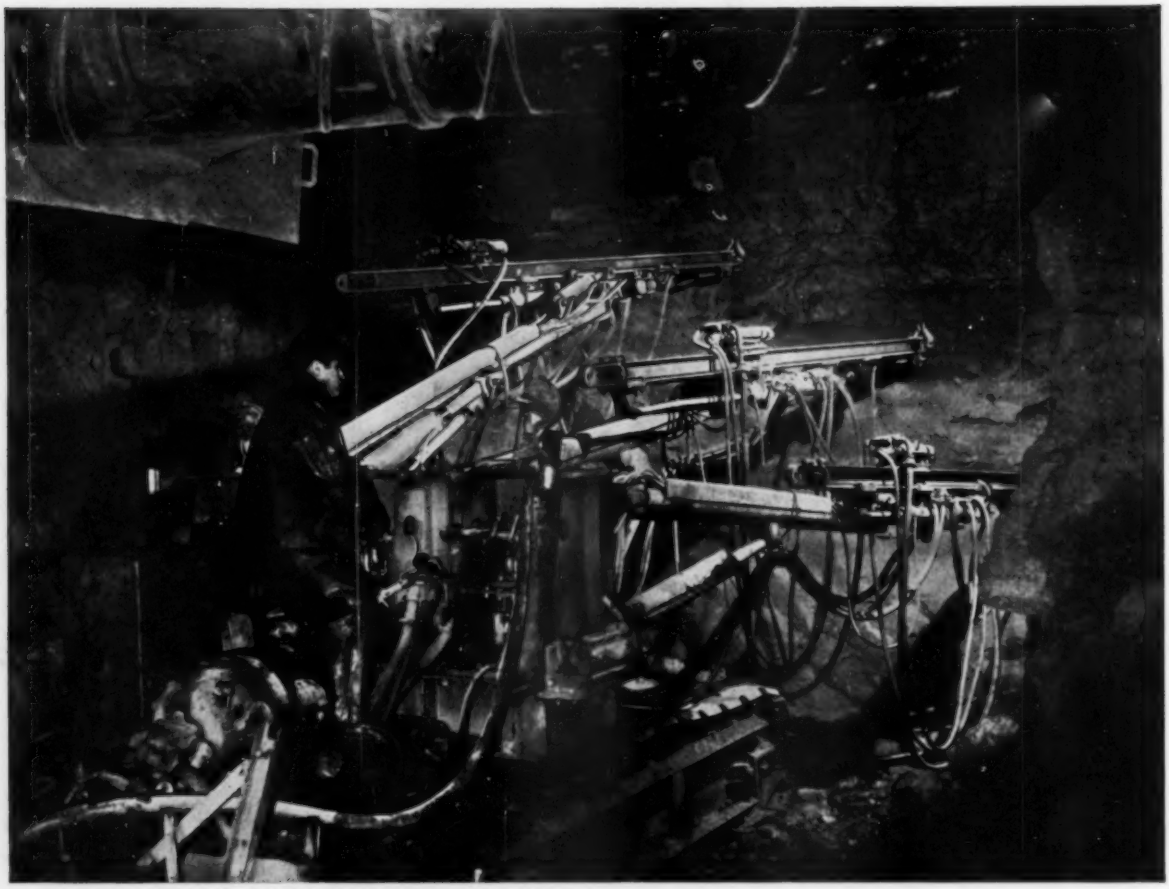
Working Models

Precision working models of many types of machines, drives, and mechanisms can be fabricated with the FAC universal construction system developed in Sweden. Principles and assembly methods are detailed in a new 80-page illustrated manual available for $1 from *FAC Div., 9551 Grand River Ave., Detroit 4, Mich.*

News & Notes

Mine & Smelter Supply Co. has consolidated its Marcy Mill Div. and the Colorado Iron Works Co. into the Mfg Div. of Mine & Smelter. . . . *F. L. Smidth's* Unax kiln for lime, ore, cement has been scaled as a

model (see above) for use at exhibitions. . . . *National Mine Service Co.* has established a new Canadian subsidiary, National Mine Service (Canada) Ltd. . . . Further diversifying and expanding, *Eagle-Picher Co.* has just completed a $2.5-million diatomaceous earth processing plant near Lovelock, Nev. . . . *Gardner-Denver Co.* announces the winning slogan in its recent contest: Equipment Today for the Challenge of Tomorrow. . . . West Coast Engine & Eqpt. Co. is new Northern California distributor for Kue-Ken jaw and gyratory crushers by *Straub Mfg. Co. Inc.* . . . *KW-Dart Truck Co.* has started construction on a new 112,000 sq ft building in Kansas City.



With this Ingersoll-Rand

HYDRA-BOOM MINE JUMBO

one operator can set up 3 drills in 3 minutes!

Time-wasting, muscle-straining manual setups are out when a Hydra-Boom jumbo moves in on air-powered crawlers and heavy-duty drifters are spotted on the face by smooth, powerful, fast-acting hydraulically operated booms. The touch of a throttle, raises, lowers, extends, retracts, pivots, dumps and swings each drill into position in a matter of seconds. Setup time is converted into drilling time.

This compact, three-drill unit is just one example of the many jumbo combinations available with I-R Hydra-Boom mounted drills. Units of any size and number of drills can be supplied to meet every mining requirement to best advantage. Hydra-Boom features include heavier seamless steel booms and bigger double-acting cylinders that move faster, hold better and eliminate creeping or settling.

For the fastest in setups and the easiest operating mine jumbo you ever saw, look into the advantages of I-R Hydra-Booms. Ask your Ingersoll-Rand man for complete information, or send for a copy of new Bulletin No. 4196.

Ingersoll-Rand

11 Broadway, New York 4, N.Y.

A Constant Standard of Quality in Everything You Need For Drilling Rock

(21) DIPPER DREDGE: River dredging of sand and gravel is described in a 4-page illustrated technical article offered by the *Ellicott Machine Corp.* Problems faced in dredging, processing, and marketing coarse and fine aggregates are discussed in detail, comparing old and new methods with bucket ladder dredge and dipper dredge.

(22) BELT FASTENERS: *Crescent Belt Fastener Co. Inc.* offers new type joining for conveyor belting in a bulletin complete with photographs. It shows how the countersunk-head Crescent rivets driven flush with the surface of the Crescent plate leave a smooth surface, reducing wear.

(23) AIR PHOTO INTERPRETATION OF SOILS AND GEOLOGY: A 4-page folder by *Aero Service Corp.* reports that soil texture, plasticity, and internal and external drainage can be determined by experienced photo-interpreters. Area geology can be mapped and estimates of difficulty of excavation, susceptibility to slides, depth of bedded rock, and rock types can be made at low cost.

(24) FORMULA FOR HIGH PRODUCTION: A booklet describing the *Caterpillar Tractor Co.* line of Cat-built Traxcavators and attachments illustrates the uses and advantages of these heavy-duty loaders and excavators.

(25) VIBRATORS: A *Syntron Co.* catalog supplies data on 14 vibrators, ranging from models handling less than 1 cu ft to ones that vibrate bins and bunkers containing bulk materials weighing in excess of 150 tons.

(26) DUAL-PURPOSE LOADER: Details on a new pigloading machine, model 188-D, can be obtained from *Long Co.* A special swing boom makes it versatile for piggyback bridge conveyors as well as shuttle cars. It is claimed the lowest, high-capacity loader in use today.

FREE LITERATURE

(27) GAS ENGINES: A series of three fliers published by *Ingersoll-Rand Co.* details a line of 4-cycle, V-angle gas engines designed for supplying power to industry. The three engines are the PJVG, horsepower range 220 to 295; the PSVG, with a range of 408 to 816 hp; and the PKVG, with a 880 to 1760-hp range.

(28) PHONE SYSTEM: *Femco Inc.* has a replacement model Trolleyphone with plug-in parts for quick replacement to minimize downtime.

New model 3000 (shown) has small, steel-cased transceiver unit, heavy-duty speaker, and new microphone.

(29) SUBMERSIBLE MOTORS: Information on a complete line of submersible a-c electric motors for direct coupling to pumps which must operate continuously while submerged in oil, water, or liquid chemicals, is obtainable from *Reliance Electric & Engineering Co.*

(30) FLEXIBLE PIPE & JOINTS: *General Rubber Corp.* has released a 6-page bulletin, catalog 575, describing expansion joints and flexible pipe for power stations, air conditioning systems, water and sewerage works, and as flexible connections in pressure and vacuum systems handling water, brine, gases, and chemicals.

(31) TRACK INSPECTION KIT: *L. B. Foster Co.* has prepared an instructional kit for plant engineers who inspect surface railroad trackage. It provides a checklist for determining the general condition of the track, with special forms for a permanent record and for requisition memos on new equipment.

(32) PERFORATED MATERIALS: *Harrington & King Perforating Co. Inc.* has new 156-page catalog 75 showing how perforated metals are used for engineering purposes in mining processing as well as a number of other industrial fields.

(33) DIESEL CRAWLER TRACTOR: An *International Harvester Co.* catalog describes the 55.7 hp TD-9 tractor plus a complete line of matching equipment and attachments.

(34) SONIC SIFTING MACHINES: *United Specialties Co.* presents a 28-page booklet on sound vibrations applied to sifting, describing the construction of the NoVo-Screen sifting machines and giving an analysis of sound vibrations in charts and illustrations. Bulletins 1, 2, and 3 show the Shallfix apparatus for quality control, large scale analysis, and analysis sifting.

(35) PLASTIC PIPE: *Republic Steel* presents a new brochure on plastic pipe for industry, describing the characteristics of the corrosion-resistant, durable pipe for jet pumps, electrical conduits, water lines and other installations. Charts and diagrams dramatize the capacity of this pipe for liquids and gases encountered in mining.

mail this post card for more information

10

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after January 15, 1959—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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Company_____

Street_____

City and Zone_____ State_____

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11	12	13	14	15	16	17	18	19	20
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51	52	53	54	55	56	57	58	59	60
61	62	63	64						

Students should write direct to manufacturer.

(36) EARTHMOVING MACHINERY: The *John Deere Plow Co.* reports a new earthmoving team that pays bigger profits. The low-cost combination of an 820 diesel tractor with an 8-yd Hancock elevating scraper will dig, load, haul, and spread from 80 to 110 cu yd per hr on hauls of 450 to 1000 ft.

(37) HYDRAULIC BULLDOZERS: *J. I. Case Co.* pictures its Tilt-Crown dozer in a pamphlet describing models 1000 and 800 with 100 hp and 80 hp, respectively. Special features include power-tilting blade that turns hydraulically and power-shift with counter-rotation, to push dirt in both directions, plus exclusive 3-way power steering.

(38) BENEFICIATION EQUIPMENT: A *Morse Bros. Machinery Co.* brochure covers ore feeders, vibrating screens, crushing rolls, sand pumps, bin gates, and concentrating jigs. Bulletin 579 illustrates these machines with charts and records of their efficiency.

(39) COBALT & ALLOYS: The *Cobalt Information Center* has prepared this 125-page reference work by F. R. Morral with a summary of allotropy and phase diagrams for the cobalt binary alloys as well as 900 references to binary, ternary, and quaternary systems.

(40) DUST COLLECTOR: *Buell Engineering Co.* offers an 8-page bulletin discussing a recently installed dust collection system that collects nearly 5 tph. First and second stage collectors comprise 48 cyclones and two giant twin-section electric precipitators.

(41) DRYING FEEDERS: *Syntron Co.* supplies information on its new drying feeders which feature self-contained, direct-panel heated troughs. These are electromagnetic feeders with rate-control feeding and efficient bulk materials in-transit drying.

(42) HEAVY-DUTY FANS: *Westinghouse Electric Corp.* will supply information on new airfoil fans designed specifically for mechanical draft and other applications as forced-draft fans for combustion air supply, with inlet boxes to handle preheated air, and as induced draft fans for oil or gas firing applications. Series 4000 offers fans in 15 sizes.

(43) DIESEL ENGINES: A 12-page illustrated brochure entitled "There is a difference in Diesels" has been released by the *Detroit Diesel Engine Div.*, General Motors, discussing diesel vs gasoline engines, the difference between 2-cycle and 4-cycle engines, fuel systems, service, and other topics.

(44) EARTHMOVING EQUIPMENT: *Euclid Div.* of General Motors Corp. has just released a new brochure on its entire line of earthmoving equipment with 24 models, specifications, illustrations and important features listed. Form 326R describes these scrapers, rear dumps, bottom dumps, coal haulers, and crawlers.

(45) HIDDEN ELEMENTS: *Caterpillar Tractor Co.* has published an illustrated mining booklet covering the necessary elements of any mining job, describing the quality factors of equipment such as crawlers, wheel tractors, traxcavators, and engines.

(46) TWO-WAY RADIO: *Motorola* offers a reference primer on the entire field of the two-way radio, demonstrating a new dimension in the use of trucks and materials-handling and construction equipment.

(47) SILICONE RUBBER CABLES: To help mining engineers prepare their specifications for special electric cable installations, *National Electric Products Corp.* has published a brochure called Nepco-Sil illustrating the high temperature applications of this electrical cable, complete with charts and photographs, and physical specifications.

(48) MOTORS: *Louis Allis Co.* has released information concerning new Climatized vertical hollow-shaft motors and enclosed Pancake motors in their bulletins 2450 and 2100, respectively. These motors are used in petroleum, public utility, and industrial pumping stations; and for machine tools, roof-ventilating fans, and other space-cramped duty.

(49) CRAWLER TRACTORS: *Caterpillar Tractor Co.* presents a comprehensive discussion of the capabilities of its large tractors in its pamphlet called "Increase Power, Production, Profit." This 12-page booklet points up the uses of the D8 and D9 tractors in construction, logging, mining, pipelining, and railroad applications. Brief specifications are included and photographs and drawings emphasize the features of torque converters, oil clutch, and hydraulic controls.

(50) STEEL BUILDINGS: *Truscon Steel Div.*, Republic Steel, offers a booklet picturing versatile, durable structures, completely functional, that are available in standard, mass-produced components. Detailed specifications and standardized tests are outlined in the brochure, guaranteeing exact quality.

(51) ION EXCHANGE REGENERATION: Ten methods of ion exchange regeneration are discussed in technical reprint T-159 of the *Graver Water Conditioning Co.* The paper describes methods, controls, and equipment needed, complete with illustrations.

(52) THERMOPRUF CHAIN: *Allis-Chalmers* introduces a chain which provides a third more heat transfer surface in new bulletin 22B8565A. Information is included on use in wet process cement kilns and lime sludge kilns where it reduces costs and wear.

(53) CONTINUOUS BORER: *Goodman Mfg. Co.* describes a new variable height continuous borer in its catalog G-136. This type 425 has greater maneuverability with a 2-ft adjustable cutting height. Its rapid progress as it bores into coal reduces the possibility of roof deterioration and accounts for decreased mine section maintenance.

(54) HOSE VALVES: *Carl Buck & Assocs.* offers information on using Camac hose valves to regulate or shut off flow. Light aluminum construction provides minimum weight drag and valves can be slipped on without disconnecting hose.

(55) SLING CHAINS: Of interest to operating and maintenance personnel in industrial plants is this catalog of *American Chain & Cable Co. Inc.* Registered sling chains. It lists ordering information, safety factors, specifications, care, table of wear, and inspection procedures. The catalog number is DH-105.

FIRST CLASS
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New York, N. Y.

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MINING ENGINEERING

29 WEST 39th STREET

NEW YORK 18, N. Y.

"Not merely to sell; but to serve . . . not only to make good steel products; but to make them still better . . . not only to fulfill today's requirements; but to anticipate tomorrow's—these are the principles that constantly guide CF&I."

G. F. Franz
President

Grinding Mill Bulletin #4

In line with our company policy—service as well as sales—CF&I is presenting this series of ads on grinding ball rationing in the makeup charge. We trust that these ads will help grinding mill operators—by providing information that will help increase the efficiency and productive capacity of their ball mills.

General Method of Rationing the Makeup Charge

These facts have been outlined in previous ads in this series: (1) that determining the optimum size assortment of grinding balls for a makeup charge is a practical means of improving mill operation; (2) that the best makeup charge of one-size ball should be established before a rationed makeup charge is attempted; (3) that over-size ball additions are preferable to under-size additions in general, although both reduce mill efficiency; (4) that radical changes in the size of the balls to be added is not good practice. Now let us look at methods that are regarded as good practice.

If it is determined that there is a shortage of small balls in the seasoned charge, part of the makeup charge may be made up by smaller balls of one or more sizes. If there is a problem of tramp oversize in the grinding circuit, a portion of the makeup charge may be replaced by a ball of larger diameter.

In many cement plants, the seasoned charge in the mill contains too many balls that have worn to small and irregular shapes—so that they give ineffective contact. These small and "cull" balls take up space that could be better utilized by larger spherical balls which would grind more effectively. In order to increase the ratio of larger balls in the charge, the mills are periodically dumped; the charge screened; the larger balls returned to the mill; and new balls are added to make up for those cull balls which are removed.

Steps In Working Out The Ball Ration

Complete records should be kept:

(1) so that the throughput of the mill, ball wear and power consumption are known. It is also well to record liner wear, although this requires observation over a long period of time.

(2) of feed, discharge, classifier overflow, and classifier sands screen analyses. Classifier sands size structure will give indications as to whether smaller or larger balls in the charge will give better results.

(3) to show the effect of any change in ball addition on: the mill throughput, power consumption per ton and ball wear in pounds per ton. These changes will affect the size structure of the mill discharge as well as the classifier overflow and sands.

Before it is assumed that the full effects of a change in ball additions have occurred, the ball wear pattern should be given time to reach its new equilibrium. This will involve the amount of time required for the old ball charge to be entirely replaced by the new charge. For example, if the ball load in the mill is to be maintained at 100,000 lbs., and 1000 lbs. of balls are added per day to maintain that ball level, it is reasonable to assume that more than three months will be needed in which to complete the modified ball charge.

If the new makeup charge is one that would increase the rate of comminution of the ball mill, and *if* the new ball charge reaches its equilibrium *without* an increase in feed rate: the new charge will *not* show an increase in throughput; the steel consumption will be too high—due to steel on steel wear; and steel consumption per ton of ore ground will be unnecessarily high. Therefore, to prove the value of a change in ball ration, it is important that care be exercised to keep the mill feed at capacity at all times.

Rules, studies and formulae for analyzing classifier sands data, mill feed or dumped ball charges, are discussed in the article on which this ad is based.* Too much space would be required to cover this material here. However, CF&I's mining department engineers are thoroughly familiar with good practices in grinding ball operations, and are ready to help you with your specific problems. CF&I is also ready to provide special analysis steel grinding balls which will give you maximum production efficiency in your grinding mill. CF&I Grinding Balls are available in all standard diameters from ¾" to 5". They are carefully inspected throughout production and immediately prior to shipment to ensure that they are free from surface pits, circumferential ridges or other surface defects. You'll find them ideally suited to helping you work out the correct ball ration for your specific operations.

**For a reprint of the article on which this series is based, please write on your company letterhead to: Mining Supply Department, The Colorado Fuel and Iron Corporation, P. O. Box 1920, Denver, Colorado.*

OTHER CF&I STEEL PRODUCTS FOR THE MINING INDUSTRY

CF&I Grinding Rods · CF&I Grader Blades · CF&I Industrial Screens
CF&I Mine Rail and Accessories · Wickwire Rope · CF&I Rock Bolts

FORGED STEEL GRINDING BALLS
THE COLORADO FUEL AND IRON CORPORATION

Albuquerque · Amarillo · Atlanta · Billings · Boise · Boston · Buffalo · Butte · Chicago · Denver · Detroit · El Paso · Ft. Worth · Houston
Kansas City · Lincoln · Los Angeles · New Orleans · New York · Oakland · Oklahoma City · Philadelphia · Phoenix · Portland · Pueblo
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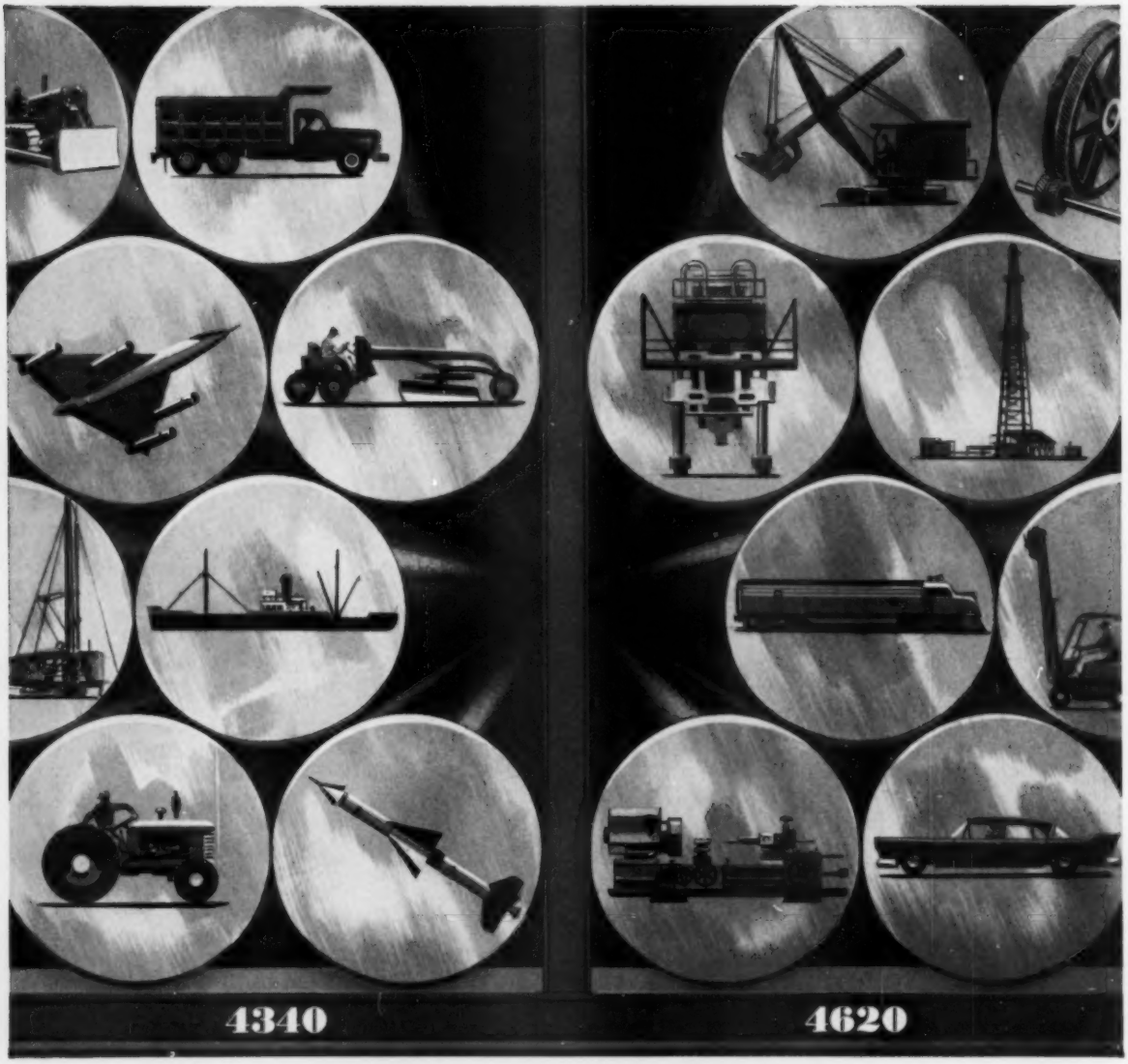


No matter what you make...

look to these two general purpose steels to standardize, simplify, and save money!

4340 THROUGH-HARDENING

4340 stands alone among medium carbon steels in its ability to provide maximum strength, ductility, toughness and resistance to fatigue in parts of medium to heavy cross section.

4620 CARBURIZING

4620 is a carburizing type that has consistently proved itself the ideal steel for a wide variety of carburized parts. 4620 is easy to carburize and has a minimum tendency toward distortion in heat treatment.

AMERICAN STEEL WAREHOUSE ASS'N.

Easy to Get *... Both these steels are carried by many Steel Service Centers from coast to coast* ... ready for delivery on a "next door" basis. For a list of names and addresses of Steel Service Centers that carry AISI 4340 and 4620, write us.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street New York 5, N.Y.

INCO TRADE MARK

Strong Lead-Zinc Study Program

Nineteen producers of lead and zinc have joined in a program designed to probe new uses for their metals and increase research. Schrade F. Radtke, newly appointed director of the program, comments that "although the position in large, vital, and traditional uses of these metals is solid, it does not do justice to their true potential. The lead and zinc industries must keep pace . . ." This new program of pace-keeping will be financed by assessments, each producer participant supporting according to his total output. No expenditure limit has been set—every program approved by development committees of the American Zinc Institute and the Lead Industries Assn. will get funds according to its determined value . . . . Meanwhile, the Federal Government is "actively considering" suggesting formation of an international study group on lead and zinc and the Bureau of Mines is emphasizing research on extraction and efficient operations . . . . Mine output of lead was down about 21 pct in the first half of this year . . . . American Smelting & Refining has developed a continuous process for making zinc foil in sheets 0.005 to 0.001 in. thick, expects the foil to be cheaper than comparable aluminum sheets.

Copper Production Increased

Kennecott Copper has hiked its copper output 3800 tons per month by shifting from a 5 to a 6-day workweek at its western divisions. The Arizona mines of Phelps Dodge at Morenci, Ajo, and Bisbee, were also given a boost, their workweeks rising to five days from four. Both major upsteps were optimistically put forward during a period of only fair domestic demand.

Aluminum Upstep

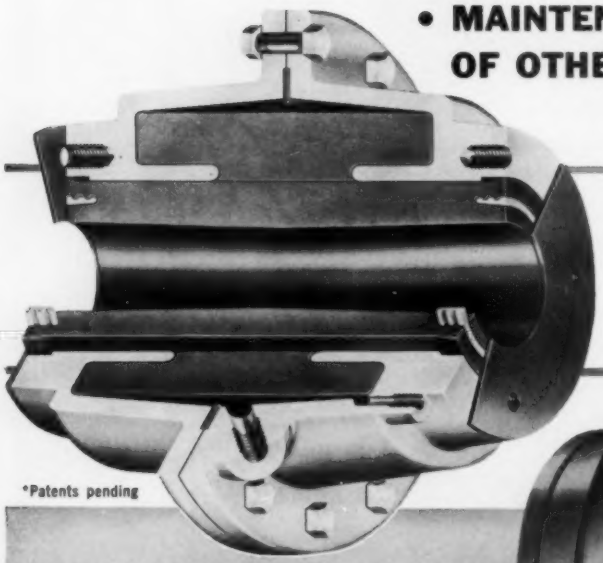
Aluminum Co. of America has put a new potline on stream at Massena, N. Y., and plans to put a second line into production October 15. The Massena plant is the first industrial user of power from the St. Lawrence project . . . . Reynolds Metals Co. has reopened one Jones Mills, Ark., potline and Kaiser Aluminum & Chemical Corp. is again using a Mead, Wash., line that was closed when industry sales fell . . . . Most producers seem to believe inventory trimming by consumers has ended, but still complain of heavy stocks in their own hands.

Nicaro Buyer?

North American Nickel Corp., a new mining firm, has been formed by Bunker Hill Co., St. Joseph Lead Co., Falconbridge Nickel Co. and Blyth & Co., investment company, for making bids on the Government-owned Nicaro nickel plant in Cuba. If the facility is put up for sale, as company officials believe it will be, North American Nickel will make its bid and seek financing. Incorporation requirements called for raising $100,000.

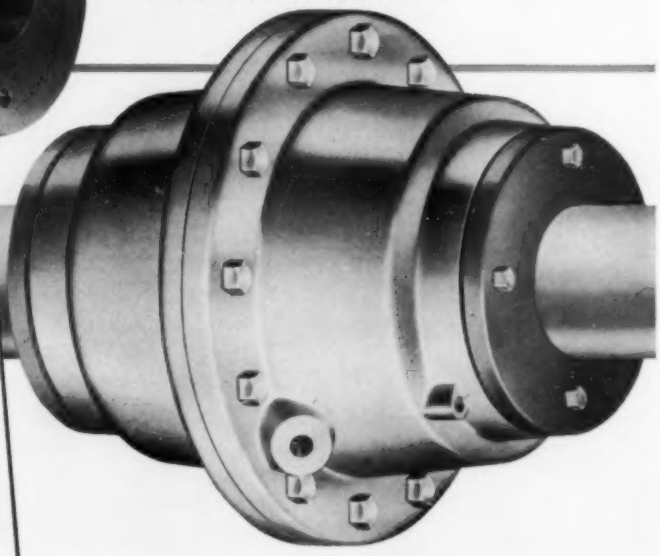
CLARKSON SLURRY VALVE

- **FLOW CONTROLLED–AS IT SHOULD BE —THROUGH A VENTURI RESTRICTION**
- **MAINTENANCE COST AS LOW AS 10% OF OTHER RUBBER VALVES**



*Patents pending

Clarkson Valve, Model C . . . an advanced design for control, with plant air, of abrasive and corrosive slurries.



- ✓ Jacketed steel construction — Two piece housing.
- ✓ Constrictor "muscle" of rubber creates the centered orifice.
- ✓ Full length 1" thick liner of pure gum or Neoprene at low cost.
- ✓ Operation with air or hydraulic—remote if desired.
- ✓ Rubber Sleeve Liner replaced without dismantling—or even taking valve completely off the line.
- ✓ Lowest pressure drop of any valve—idealized laminar flow pattern.
- ✓ Model C sizes: 1½", 2", 3" and 4"—full diameter.

The Clarkson Company has long been identified in the field of controls. Clarkson Valves maintain the same high standards of quality and performance at low prices that have made the Clarkson Feeders in Stainless Steel and Inert Plastics known to all mining operations and other industries.

Clarkson Feeders & Valves
Write for Details

THE CLARKSON COMPANY
A division of Equipment Engineers Inc.
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SULPHUR

ONE OF THE FOUR STRONG PILLARS OF PROCESSING

SULPHUR *and* STEEL

This fact may not be too well known: the steel industry consumes about 7% of all the elemental Sulphur or Sulphur existing in the form of sulphur gases, etc., produced in this country. Most of this Sulphur serves the steel industry in the form of Sulphuric Acid where it is used in pickling steel products but also to a considerable extent in plating them. And certain machine steels carry an appreciable amount of 'planted' Sulphur to impart desirable machining qualities. Seven percent of the total elemental Sulphur and equivalent Sulphur tonnage is quite substantial. Its use in steel emphasizes the importance of Sulphur to our whole economy. Much of this tonnage of steel-used Sulphur starts out at our mines in Texas where we serve as a major supplier of Sulphur to the manufacturers of Sulphuric Acid.

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58 NORDBERG GRINDING MILLS in Ore Concentration Plant

. . . largest iron ore mill installation under one roof in the world

Here, stretching about a quarter of a mile, are 27 Nordberg Rod Mills and 27 Nordberg Ball Mills in a concentrator building up in the Lake Superior Iron Range of Minnesota. The 54—10 foot diameter Nordberg mills reduce hard, abrasive Taconite Iron Ore to the fineness of flour. Four additional Nordberg mills serve as reserve replacement units.

This is but one example of the way in which Nordberg Grinding Mills, in sizes from 6 to 13 feet in diameter and up to 50 feet in length, are successfully serving the ore, mineral, cement and chemical processing industries of the world.

Years of specialized experience in the design, manufacture and installation of process machinery assure you that you can count on Nordberg, its machinery and "know how" to add efficiency and economy to *your* processing operations. For complete details, write for the Nordberg Grinding Mill Bulletin 232.

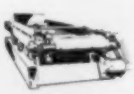
NORDBERG MFG. CO., Milwaukee 1, Wis.

SYMONS PRIMARY GYRATORY CRUSHERS

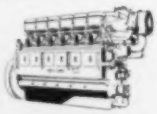
SYMONS CONE CRUSHERS

NORDBERG MINE HOISTS

SYMONS GRIZZLIES and SCREENS



SYMONS VIBRATING SCREENS



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NORDBERG MACHINERY

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GM158

Humphrey on Iron

Senator Hubert H. Humphrey of Minnesota has clarified his state's attitude on the situation of iron ore imports and iron state taxes (covered briefly in *Trends*, September 1957) in a letter to the editor of *Business Week* which discusses that magazine's article of Aug. 9, 1958. The Humphrey letter, in part, follows:

". . . it is stated that Minnesota's percentage of all U.S. iron ore purchases has dropped since 1946 from 68 pct to last year's 49 pct. The inference, to the uncritical reader, is that Minnesota's gross tonnage has dropped throughout that period. But, as you know, steel capacity has greatly increased since 1946, so that while it is true the percentage of iron ore purchases has dropped, the gross tonnage of Minnesota production, up until this year of unusually low steel production, has been running at a very high rate . . . .

"Minnesota has no objection to imports of iron ore. We recognize that an expanding steel industry must draw iron ore from whatever source it can.... Minnesota is disturbed, however, when in those years when steel production drops off from the norm the steel companies have in the last two such years decreased their purchases of iron ore from Minnesota by an amount disproportionately greater than the drop in steel production, while at the same time continuing to increase the rate of imports of iron ore . . . .

"The question is being asked in Minnesota whether this means that . . . . leaders of the steel industry are not deliberately making a bad situation in Minnesota iron mining worse, applying the *squeeze* to the Minnesota Iron Range at a time when the recession in the steel industry would dictate a sharp reduction in iron mining everywhere, including the mines owned by the American steel corporations abroad. The suggestion is being made that the steel corporations are not interested in increasing employment in the iron mines of Minnesota any more than they have to, until the decision has been made in the legislature on Minnesota iron ore taxes. Whether this is a valid criticism, I do not know.

"But I do know that the state goverment of Minnesota deserves to have the facts laid out before it on the table . . . ."

Mesabi Case to Federal Court

Mesabi Iron Co.'s rumbling controversy with Reserve Mining Co. over the latter's accounting procedures in its use of a Mesabi iron ore field has now been delegated to hearings by the Federal District Court of Minnesota. The case formerly on the state level will come up in Duluth on October 3, 1958.

Mesabi, as President Arnold Hoffman tells stockholders in a recent interim report, contends that: "In reports to Mesabi, Reserve admits to having mined nearly 30 million tons of crude iron ore from the Peters lease from the commencement of operations in 1953 up to January 1, 1958, from which approximately 10 million tons of iron pellets have been produced. Even at the minimum price for this product arbitrarily assigned by Reserve Mining, its dollar value is admittedly in excess of $100 million. To date, Mesabi has received no consideration whatever for this impressive production which has been exclusively consumed by the steel making plants of Armco and Republic Steel—co-equal owners of Reserve Mining. On the contrary, Reserve blandly informs Mesabi that operations not only have shown no profit, but, indeed, have been conducted at a substantial loss."

The case coming up in Duluth will consider Mesabi's motion seeking to vacate the temporary stay heretofore obtained by Reserve, and also Reserve's motion seeking to compel Mesabi to resume arbitration.

The End of an Era

With its lifting of restrictions on uranium use this summer the AEC did more than offer uranium producers an opportunity to sell their product direct to commercial users here and abroad; it impassably marked the end of an era of secrecy and control. Within a decade this country has moved from a position where we had hope, probably foolish, of monopolizing sources of the metal and knowledge of its use, and of thereby hoarding the weapon to end all weapons. It appears that the U. S. is in full retreat from that position.

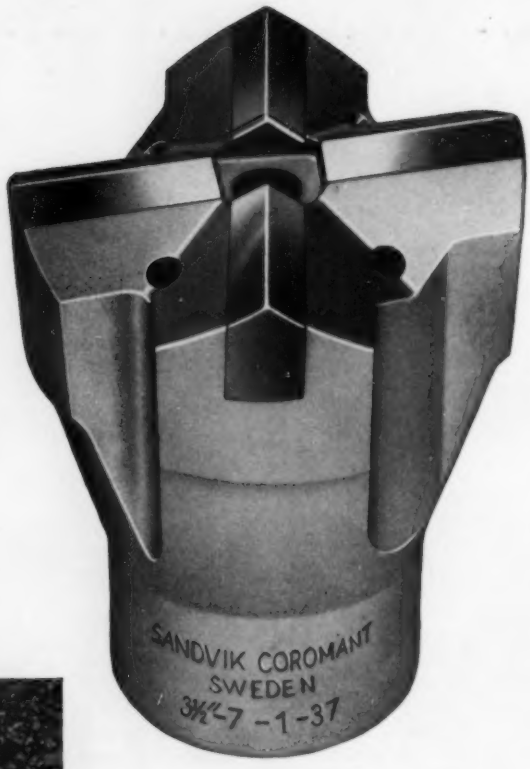
Technologically, the announcement will spur interest on the part of uranium miners in carrying their operations at least one or two refining steps further.

Most uranium mills have been scanning the U.S. and unrestricted foreign areas for potential customers and many have already received inquiries. The AEC remains a competitor, however—though competitor may not be the precise term—since it appears the commission will continue to be in the uranium business as a seller. To quote AEC release A-158: "Either normal uranium, purchased from private industries, *or depleted uranium now available from the commission* may be used for such purposes."

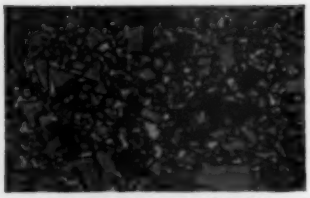
How large the market will be is still unknown, but a usable yardstick can be taken from the commission's note that the prewar market in the fields of ceramics, glass, and photography totaled about 200 tons per year.

Davison Div. of W. R. Grace & Co. has claimed the first quantity purchases of private uranium concentrates for conversion to nuclear reactor feed materials. Original material came from Uranium Reduction in Moab, Utah, and, after reduction to high purity uranium metal, the product went to Bridgeport Brass Co. for extrusion into fuel element rods.

Longer bit life— with *new* Sandvik Coromant Bits



Sandvik Coromant Tungsten Carbide (Microphoto) Uniformity of size, even distribution of grain are marked. Free from porosity and impurities —therefore stronger, longer-lived.



Low quality Tungsten Carbide (Microphoto) Black marks are contaminations caused by deficient production control. They weaken the carbide, reduce its working life.

Sandvik Coromant Detachable Bits are Available in the following Thread Sizes and Bit Diameters

Type	Thread	Available Diameters, in Inches														
		1⅜	1½	1⅝	1¾	1⅞	2	2⅛	2¼	2⅜	2½	2¾	3	3½	4	4½	5
SHOULDER	F	x	x														
	113	x															
	H		x	x	x	x											
	115		x	x													
	D					x	x	x	x	x	x	x	x				
	K												x	x	x	x	
BOTTOMING	1" Rope			x	x	x											
	200			x	x	x											
	1¼" Rope					x	x	x	x		x		x				
	400						x		x		x						
	1½" Rope										x	x	x	x	x		
	600										x	x	x	x			
	700												x	x			
	J. 7.5														x	x	
	2" Rope													x	x	x	x

NEXT time you buy bits, specify Sandvik Coromant because they give more footage per bit, lower drilling costs. Here's why:

1 Only first-quality tungsten carbide is used —as shown in the microphotos above. This means less wear, longer life and a better job.

2 The bodies are precision-made of high quality alloy steel—tough enough to take the strain throughout the extra-long bit life.

3 The bigger Sandvik Coromant bits are all of X-design, which prevents rifling. No wonder Sandvik Coromant inserts are the most widely used in the world, drilling more than one billion feet every year.

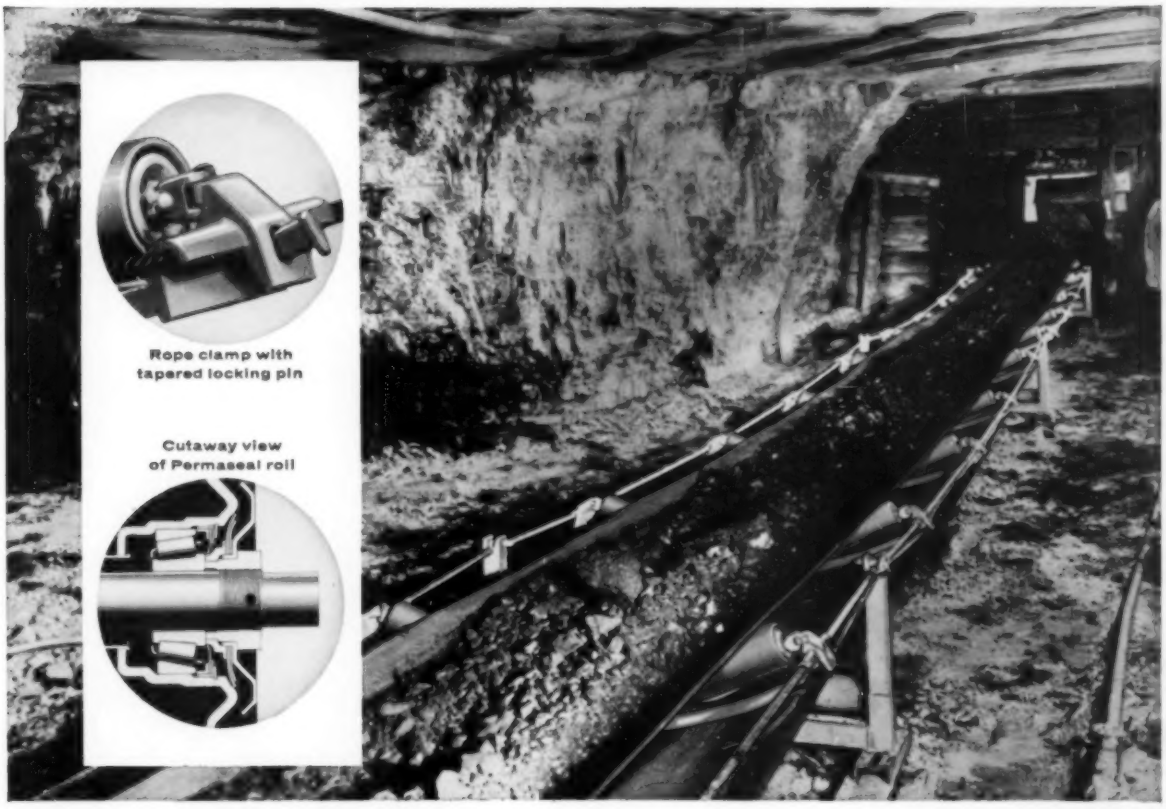
SANDVIK COROMANT bits are supplied through Atlas Copco, the world's largest manufacturer of rock drills, who also supply Sandvik Coromant integral steels — the most widely used in the world — and Sandvik Coromant extension steel equipment.

Write or phone today for further details to either of the addresses below:

610 Industrial Avenue
Paramus, New Jersey
COlfax 1-6800

Atlas Copco

930 Brittan Avenue
San Carlos, California
LYtell 1-0375



JEFFREY BELT CONVEYORS

(wire rope type)

have these advantages . . .

Low first cost—Easy and economical to set up with fewer parts; need no belt training idlers; intermediate sections require no cover plates; two parallel wire ropes replace heavy rigid type angles or channel side frames.

Low operating costs—Fewer components to handle or transport saves time in extending or retracting. Little or no spillage means less clean-up time.

Long belt life—Lasts longer as load impact is absorbed by spring effect of wire ropes when load passes over troughing idlers.

Permaseal idlers—Have Timken tapered roller bearings protected by two flexible diaphragm seals. Inner seal retains lubricant. Outer seal keeps out dirt. Prelubricated for years of maintenance-free service.

Spacing of idlers—Can be changed easily to suit material or mine conditions.

Rope clamp for cradle bracket—Rope clamps with "no loss" tapered locking pins prevent creeping. Cradle brackets and support stands hold ropes parallel. No separate spreader required.

Versatility—These conveyors can be used above or below ground to handle coal, salt, gypsum, iron ore, etc.

For more details send for bulletin 948. The Jeffrey Manufacturing Company, 865 North Fourth Street, Columbus 16, Ohio.

JEFFREY

MINING • CONVEYING • PROCESSING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

High in the Peruvian Andes

RIO PALLANGA gets Maximum Profit with CYANAMID REAGENTS

Optimum cost-plus-tails varies for every ore and property in every mining district as every metallurgist knows.

But the most economic recovery at a particular mill can only be attained by careful evaluation of all milling costs, patient testing . . . and the right combination of Cyanamid Reagents. RIO PALLANGA proves that!

SINDICATO MINERO RIO PALLANGA treats 350 tpd of an unusual lead-zinc ore by straight flotation. By study of reagent combinations and overall mill economics, the mill staff working with a Cyanamid Field Engineer evolved this very low-cost reagent set-up:

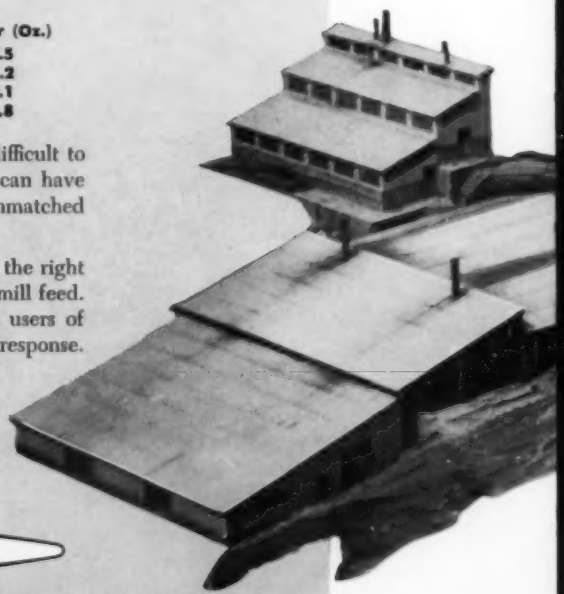
Lead Flotation	Lb/ton	Zinc Flotation	Lb/ton
AEROFROTH® 70 Frother	0.017	SODIUM AEROFLOAT® Promoter	0.074
AEROFLOAT® 25 Promoter	0.006	Copper Sulphate	0.517
AERO® Thiocarbanilide 130	0.188	Screened Lime	1.106
Sodium Cyanide	0.003		
Zinc Sulphate	0.102		
Sodium Silicate	0.068		

At Rio Pallanga lead concentrate grade is deliberately lowered by floating some pyrite in order to get the optimum local smelter rate. To avoid excessive grinding costs (which would be required to liberate finely disseminated sphalerite in the dolomite gangue), somewhat higher-than-average zinc tailings are tolerated. Sodium silicate is used to help depress quartz. Typical mill assays are:

	% Zinc	% Lead	Silver (Oz.)
Heads	5.1	4.1	7.5
Lead Concentrate	6.7	52.6	91.2
Zinc Concentrate	59.1	0.2	3.1
Tails	0.9	0.1	0.8

Whether your tonnage is large or small, whether or not your ore is difficult to beneficiate or your operating condition poses special problems, you can have the benefits of Cyanamid world-wide ore dressing experience and unmatched research background.

A Cyanamid Field Engineer stands ready to work with you to evolve the right combination of Cyanamid Reagents for lowest cost-plus-tails on your mill feed. These extra values are freely offered to both present and potential users of Cyanamid Reagents. A letter to our nearest office will bring prompt response.



CYANAMID

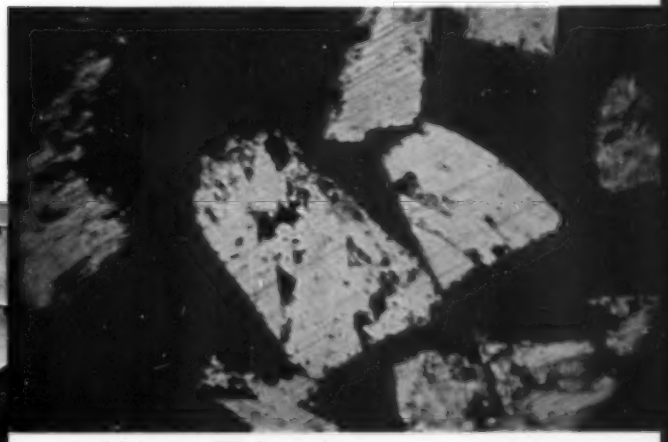
AMERICAN CYANAMID COMPANY

EXPLOSIVES AND MINING CHEMICALS DEPARTMENT

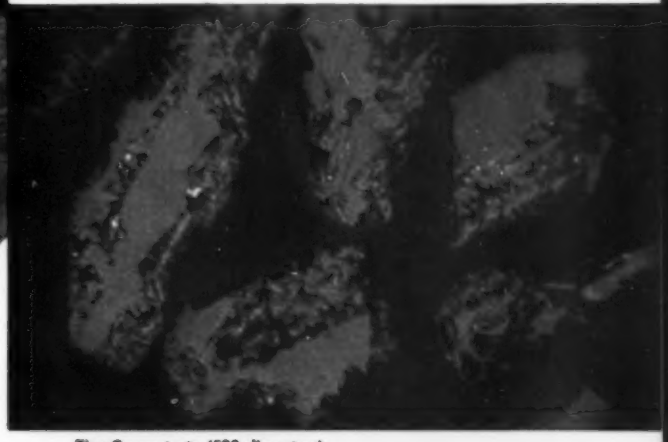
CYANAMID INTERNATIONAL — *Mining Chemicals Department*
Cable Address: Cyanamid, New York

30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

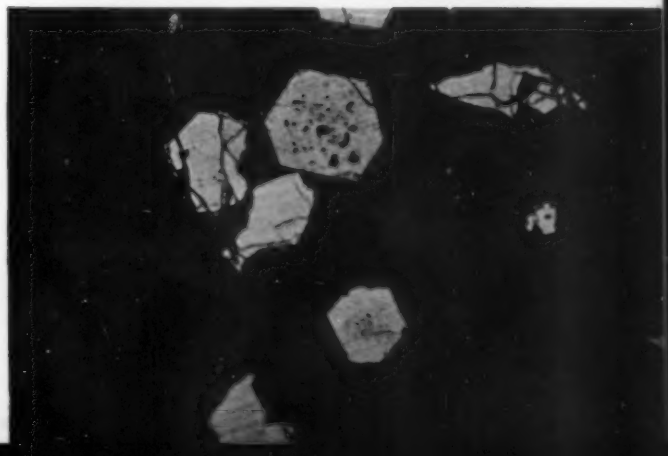
Photomicrographs are all of 100 x 500 mesh fractions of Rio Pallanga mill products. (G = Galena; P = Pyrite; S = Sphalerite.) Above shows mill feed (200 diameters). Dark minerals are calcite quartz and dolomite.



Lead Concentrate (500 diameters)

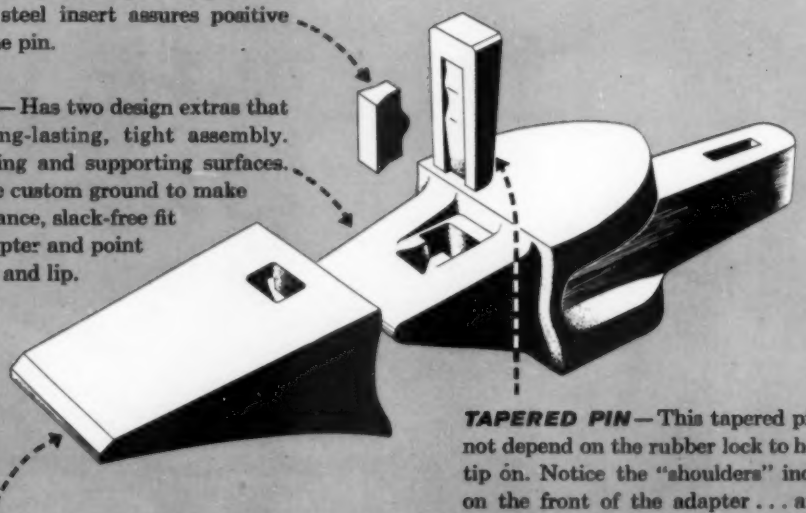


Zinc Concentrate (500 diameters)



Tailings (200 diameters)

NEW AMSCO® 2 PART TOOTH



PIN LOCK — Special high-strength rubber with a steel insert assures positive locking of the pin.

ADAPTER — Has two design extras that assure a long-lasting, tight assembly. Larger bearing and supporting surfaces. Adapters are custom ground to make a close-tolerance, slack-free fit between adapter and point and adapter and lip.

REVERSIBLE TIP — Enables you to get longer digging life while maintaining sharpness.

TAPERED PIN — This tapered pin does not depend on the rubber lock to hold the tip on. Notice the "shoulders" indicated on the front of the adapter . . . and the mating shoulders on the pin. These shoulders lock the tip in place with metal-to-metal contact. The rubber lock, in turn, locks the pin in place.

3 big features for fewer shovel shutdowns

1 You get up to four times extra wear over other 2-part teeth. We cast these new teeth of a tougher, new and special heat-treated alloy that slashes your replacement and maintenance costs.

2 These reversible teeth stay sharp, to penetrate cleanly and easily without straining your shovel. Reversing point is easy. This reversible feature is particularly important on corner teeth. It maintains digging efficiency throughout tooth life.

3 Positive locking device — Amsco's unique pin-locking design secures tip to adapter in tight, positive, metal-to-metal contact.

Order the Amsco 2-part Simplex from your local power shovel dealer.

AMERICAN Brake Shoe COMPANY

AMSCO

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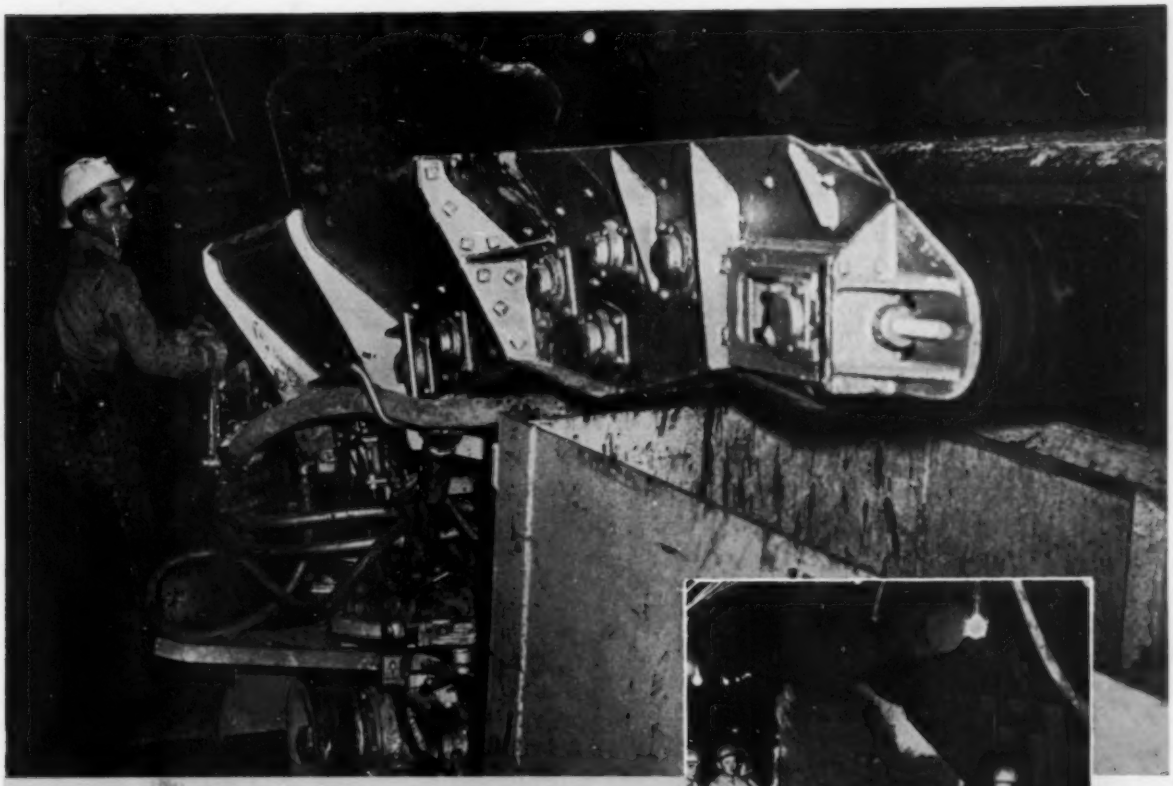
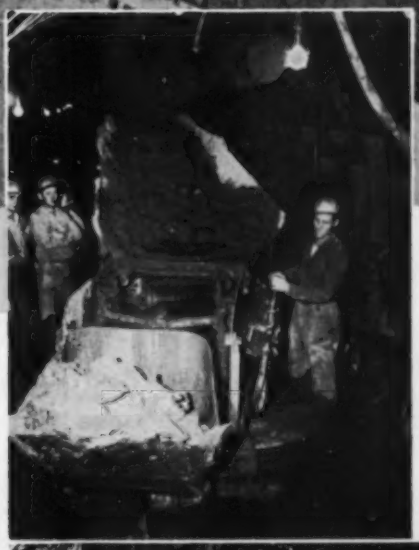
OTHER PLANTS IN: DENVER, LOS ANGELES, NEW CASTLE, DEL., OAKLAND, CAL., ST. LOUIS, JOLIETTE, QUEBEC



Eimco Model 40H Loaders are being used in many of the high speed tunnel jobs in work today. These machines are making it possible to average high daily advance footage in all types of ground.



THE DEPENDABLE EIMCO MODEL 40H

Successful contractors, the world over, who make a profit on their job and achieve records in tunnel speed, have learned through experience that you cannot beat the Model 40H for dependable, month in and month out, high performance.

There is now available the Model 40W for headings 14 feet wide — and wider.

The experienced estimator figures his cost on the basis of using dependable, efficient, low-cost Eimcos.

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LOW COST
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MAGNETITE
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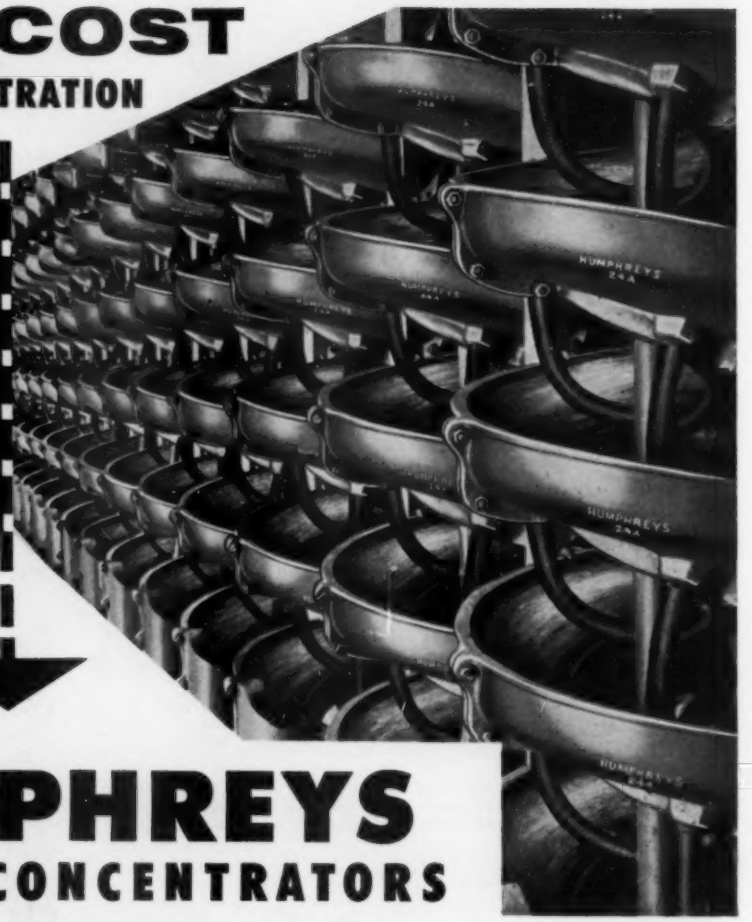

HUMPHREYS
SPIRAL CONCENTRATORS

HAVE ECONOMICALLY RECOVERED THE MINERALS LISTED ABOVE

Low cost concentration becomes a reality when you install Humphreys Spirals. Economy-minded mineral producers the world over prize these efficient concentrators, their economical installation, low maintenance costs and year-round trouble-free operation. No moving parts. Small floor space.

APPLICATIONS:

Production of a finished concentrate.

Production of a bulk concentrate of several minerals and a finished tailing in one or more stages.

Scavenging the tailing from another process for the recovery of heavy minerals.

Write today for information on metallurgical tests of your ore samples for spiral treatment.

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MINING engineering **DRIFT**

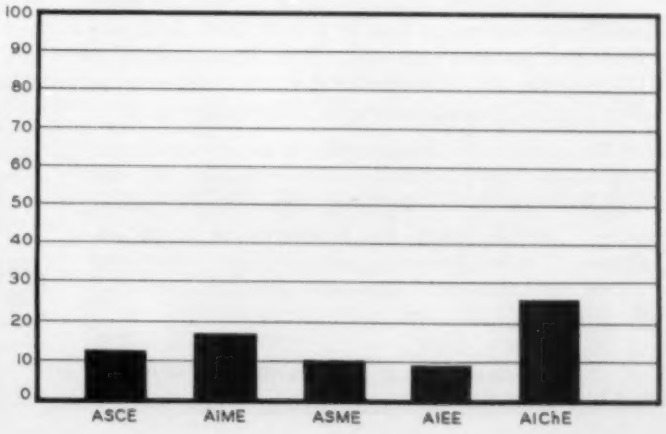
FOR YOUR INFORMATION—

In This Issue—On page 1038 you will find abstracts of the articles in this issue. They mark the start of a new feature in MINING ENGINEERING which we hope will be both useful and convenient. This feature will also carry abstracts of original meeting papers as early as it is possible to print them. For example, see page 1038 for an abstract from the AIME-ASME Joint Solid Fuels Conference. The abstracts of current articles have two purposes: for the member who wishes a quick summary of what is in this issue and for the use of librarians, indexes, and abstracting services who need a brief standardized summary of each article complete with proper reference. The abstracts are located where they are to enable members who maintain card files to clip them without damaging the article section of the issue.

SME Money—Not in this issue, but on page 1011 of the September issue, there appears a detailed analysis of SME income and expense. If you missed this page we hope you will check back and take a look at those figures. Shown graphically are the sources of SME's money and where it goes—both in percentages of the total. They should answer many questions which members ask.

United Engineering Center—The graph below tells the story in brief—where AIME stands in the Member Gift Campaign portion of the drive to raise the funds for the new United Engineering Center. We expect to bring you a more detailed report on plans for the Center in a late fall issue, provided that architectural plans have received board and governmental approval. Meanwhile you can estimate AIME's rate of progress toward its goal. The bars show how much of its goal each Society has received in pledges, plotted in percentage of the total and based on September 15 figures.

—R. A. Beals



CAT D8 TRACTOR-NO. 463 SCRAPER DIGS PROFITS OUT OF ALABAMA QUARRY

Cat D8 Tractor-No. 463 Scraper stripping overburden in mining operation near Tarrant, Ala. The haul averages 300 ft.

"I like the performance of our Caterpillar equipment," says John N. Cushman, general superintendent of the Dolcito Quarry Co., Tarrant, Ala.

Mr. Cushman is praising a Caterpillar team that is daily producing in excess of 2,000 tons of dolomite used for concrete aggregate, agricultural limestone, fluxing stone and rock dust.

A Caterpillar D8 Tractor with No. 463 Scraper strips overburden that ranges from 12 to 28 ft. thick. A Marion Back Hoe powered with a Cat D315 Engine assists in this function. The stone then is shot at a depth of about 50 ft., and a D7 pushes the rock to the quarry floor.

The D8-No. 463 combination is ideal where power and traction are needed for a short haul. The No. 463 Scraper, with all the fast, easy loading characteristics of LOWBOWL design, has a capacity of 18 cu. yd. struck, 25 cu. yd. heaped. It has straddle-mounted rear wheels with adjustable axles, high apron lift, protected cables—all the features that have made Caterpillar LOWBOWL Scrapers famous for high production.

The D8 packs 191 flywheel horsepower and 155 HP at the drawbar. It's tough, from track shoes hardened by a "water-quench" process to rugged diesel engine that uses low-cost fuels without fouling. And you have your choice of two models: torque converter drive and direct drive with the exclusive Caterpillar oil clutch.

Your Caterpillar Dealer has facts and figures showing how these big yellow machines can make a quarry operation more profitable. Ask for a demonstration.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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THE NO. 1 TRACTOR-SCRAPER COMBINATION

FLUOSOLIDS ROASTING OF DOWA'S YANAHARA SULFIDES

FluoSolids treatment of Yanahara pyrrhotite has given Japan's Dowa Mining a profitable return on copper, sulfuric acid, and iron ore and has also reduced pyrite mining costs.

by HIDESABURO KURUSHIMA and R. M. FOLEY

About 25 pct of all Japanese pyrite comes from the Yanahara mine on Honchu Island. For the past 40 years lack of an economical recovery process forced the operator, Dowa Mining Co., to sell the pyrite for its contained sulfur only, leaving 7 million tons of high grade iron ore waste. Introduction of the Dorrco FluoSolids roasting system enabled the company to make use of its iron sulfides and also to find a market for the mine's considerable pyrrhotite production.

The success of this project is of great importance to Japan's economy since it points the way toward material increase in her natural resources. Prior to use of the present process, no practical method was available for commercial exploitation of known large tonnages of pyrrhotite, while the copper content of the even larger deposits of pyrite made the roasted residue unacceptable for the iron and steel industry. In Europe, large amounts of copper-bearing pyrite cinder are given a chloridizing roast for separation of the copper and iron but this treatment is not economical in Japan where salt is imported from as far away as Egypt.

Most of Japan's sulfuric acid is produced from gases generated in the roasting and smelting of local sulfides but most of the iron ore used in steelmaking

H. KURUSHIMA is President, Dowa Mining Co. Ltd., Tokyo, Japan. R. M. FOLEY is associated with Dorr-Oliver Inc., Stamford, Conn.

is imported. In the chemical industry pyrite is the most important source of sulfur for acid making.

Yanahara Ore: The pyrite deposits at Yanahara are generally enclosed in an irregular layer of pyrrhotite, and small veins of pyrrhotite occur in the pyrite. To be commercially attractive the pyrite has had to contain about 50 pct S. To maintain this grade mining was selective, resulting in a considerable loss of pyrite in the mine because of the irregular boundary between the two minerals. Likewise, the pyrrhotite from the small veins had to be discarded by hand picking.

There was no market at all for the pyrrhotite because consumers objected to the higher freight per unit of sulfur. Additional drawbacks included the danger of spontaneous combustion in transit and storage, and the tendency of the pyrrhotite to fuse during calcination.

Dowa Mining had already successfully applied the Dorrco FluoSolids roasting system on sulfate roasting a complex sulfide concentrate containing copper, zinc and iron. This roast-leach-electrowinning process was described by the senior author in a previous paper.[1]

Because of the experience with fluidized roasting, Dowa believed that this method might be used to separate the constituents of the Yanahara iron sulfides. In this case it would be desirable to selectively sulfite the contained copper and at the same time produce a concentrated SO_2 gas suitable for conversion into sulfuric acid. If successful, the roasted calcine could be leached with dilute acid for removal of the copper and the leach residue sintered to produce lump iron ore. The iron ore would have to contain less than 0.2 pct Cu to be commercially attractive.

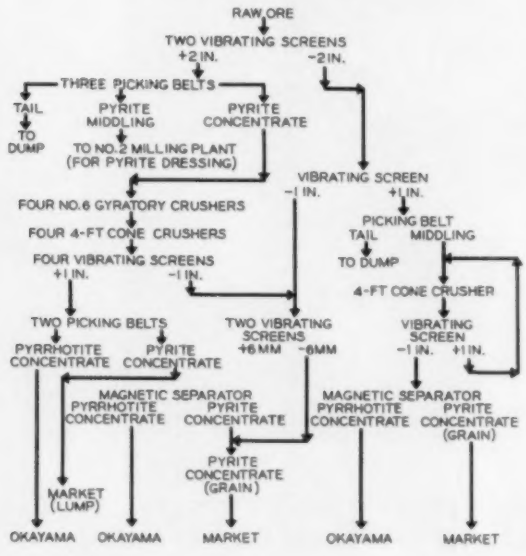
Test Program: A test program was initiated and Yanahara pyrrhotite was selected to be the test sulfide because utilization of this unmarketable material would be of greatest benefit to Dowa. Roasting tests were carried out in a 4-in. diam laboratory FluoSolids reactor. Chemical and size analyses of feed material used are given in Table I.

Nine separate tests were carried out to determine the optimum range of temperature and SO_2 concentration required to obtain high copper solubility, low iron solubility, and high oxidation of sulfur. Temperature was 600 to 700°C and the SO_2 range was 5 to 9 pct. From these tests it was concluded that the system would satisfy requirements when operated at 625 to 650°C with 7 to 8 pct SO_2 in the exit gas. It was therefore decided to erect a commercial installation at Okayama, a city about 25 miles from the mine.

Pyrrhotite feed is delivered to the plant by rail at −1 in. and stored in the open on a concrete pad where it is blended by the bedding system. The ore is crushed to −½ in. by a cone crusher and conveyed to the ball mill hopper by a skip hoist. The grinding circuit consists of a Marcy ball mill, sump tank, and a rubber lined SRL pump to deliver the slurry to the storage agitator. The feed and water additions to the grinding circuit are controlled so that a 70 to 75 pct solids slurry is produced. A rubber covered turbine agitator installed in an 8 x 8-ft wooden tank is used for surge storage and blending of the slurry. A typical chemical and size analysis of this feed is given in Tables II and III.

Two air-operated ODS pumps in alternate cycles deliver the feed to the 20-ft ID FluoSolids reactor at a uniform rate. Roasting air is supplied to the windbox of the reactor by a 250-hp centrifugal blower capable of delivering 7400 cfm at 5 psi. The dust laden gas leaving the reactor passes through two stages of cyclone collectors, a balloon flue, and a hot Cottrell for dust removal. Calcine distribution is shown in Table IV.

YANAHARA NO. 1 MILL FLOWSHEET



GEOLOGICAL MAP OF YANAHARA MINE

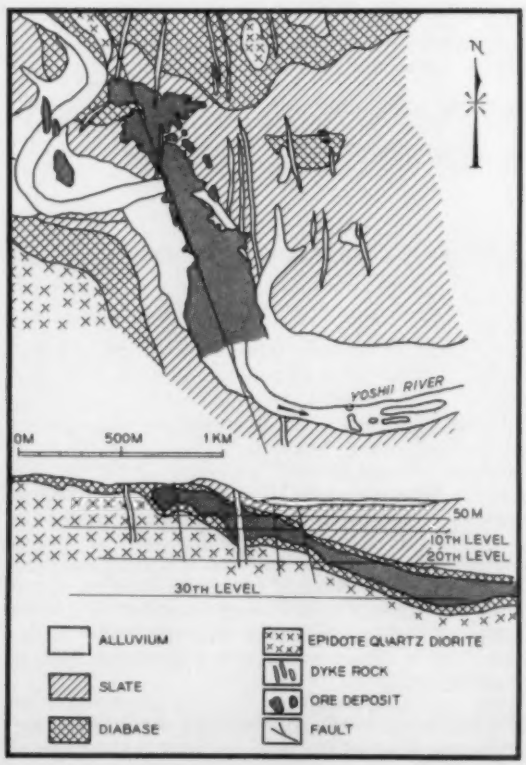


Table I. Size and Chemical Analyses of Test Feed

Grain Size Distribution	Mesh	+35	+50	+100	+150	+200	+250	−250		
	Ind. Weight, Pct	6.12	10.87	19.97	17.39	9.81	28.56	7.28		
Content	Element	Cu	Zn	Fe	S	Pb	SiO_2	Al_2O_3	MgO	$BaSO_4$
	Pct	0.39	0.61	56.33	35.65	Tr	5.57	1.18	0.26	Tr

Table II. Chemical Analysis of Roaster Feed

Elements	Cu	Fe	S	Zn	Pb	SiO_2	Al_2O_3	CaO	MgO	$BaSO_4$	Co	Ni	Se	As	F
Pct	0.67	50.44	34.68	1.08	Tr	6.33	1.55	0.26	0.24	Tr	0.006	Tr	0.002	0.002	Tr

Table III. Size Analysis of Roaster Feed

Mesh	Ind. Weight, Pct
+32	3.9
+48	7.8
+60	4.2
+80	6.1
+100	11.3
+150	14.6
+200	3.3
−200	48.8

Table IV. Distribution of Calcine

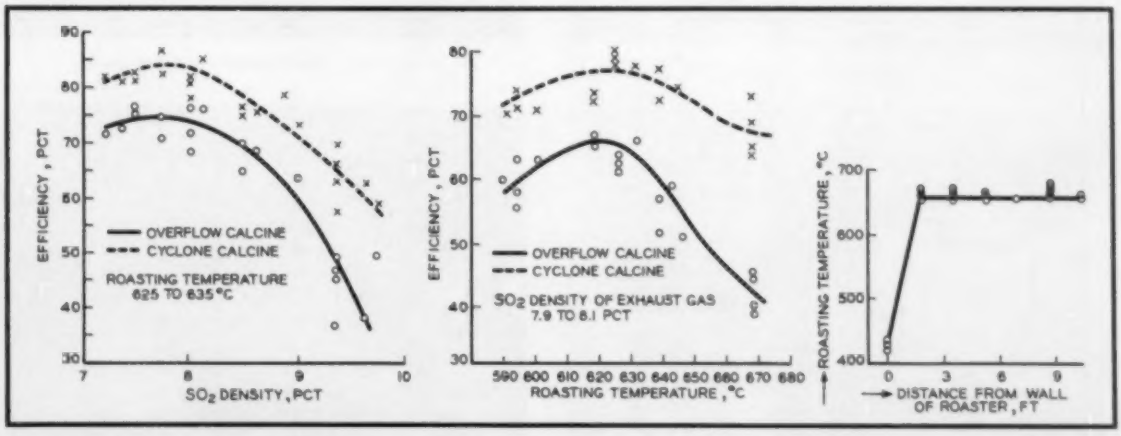
Product	Distribution, Pct
Overflow	48.5
Primary Cyclone	40.3
Secondary Cyclone	5.2
Cottrell and Flue	6.0

Table VI. Screen Analysis of Copper Distribution in Leach Residue

Mesh	Weight, Pct	Decuprized Calcine, Cu, Pct	Copper Distribution, Pct
+32	1.2	0.19	1.6
+48	7.6	0.17	8.8
+60	4.3	0.13	3.8
+80	5.5	0.12	4.5
+100	9.2	0.12	7.6
+150	16.5	0.13	14.7
+200	7.3	0.11	5.5
+250	19.1	0.12	15.7
+325	1.8	0.17	2.1
−325	27.5	0.19	35.7
Average	100.0	0.146	100.0

Table V. Leaching Efficiency of Size Fractions

	Overflow Calcine					Cyclone Calcine				
Mesh	Weight, Pct	Total Cu, Pct	Soluble Cu, Pct	Insoluble Cu, Pct	Leach Eff'y, Pct	Weight, Pct	Total Cu, Pct	Soluble Cu, Pct	Insoluble Cu, Pct	Leach Eff'y, Pct
+32	2.3	0.75	0.47	0.26	64.4	—	—	—	—	—
+48	15.6	0.55	0.36	0.19	65.5	—	—	—	—	—
+60	10.9	0.52	0.35	0.17	67.3	—	—	—	—	—
+80	23.4	0.51	0.36	0.15	70.6	—	—	—	—	—
+100	28.0	0.51	0.36	0.15	70.6	—	—	—	—	—
+150	21.4	0.48	0.35	0.13	72.9	—	—	—	—	—
+200	6.8	0.46	0.33	0.13	71.7	27.7	0.49	0.37	0.12	75.5
−200	1.6	0.58	0.49	0.09	84.5	72.3	0.74	0.61	0.13	82.4
Average	100.8	0.51	0.26	0.15	70.1	100.0	0.67	0.54	0.13	80.4



Three charts above show results of Dowa's roasting operation. LEFT: SO_2 density of exhaust gas and leaching efficiency of copper. CENTER: Roasting temperature and leaching efficiency of copper. RIGHT: Heat distribution in roaster.

Table VII. Sulfur Distribution

	Total S in Feed, Pct
Overflow calcine	1.1
Cyclone calcine	1.6
Flue and Cottrell calcine	6.0
Cooling tower	5.0
Washing tower	3.3
Mist cottrell	1.3
Absorption tower stack	3.7
98 pct acid (by difference)	78.0
Total	100.0

The reactions that occur during calcination are exothermic and much excess heat is generated in the reactor. To control temperature at the desired level, 85 lb of water per 100 lb of ore are used. Approximately 40 pct of this water is contained in the feed slurry which is maintained at 70 to 75 pct solids. The balance of the water is added automatically to the feed guns by the temperature controller.

Because the feed rate, air feed ratio, and temperature are all easily controlled with the FluoSolids system, it has been possible to obtain copper solubility data from this installation over a range of temperature and SO_2 gas concentration. These data are presented for both overflow and cyclone products in accompanying graphs. These curves illustrate that best copper solubility may be obtained with a temperature of 620 to 630°C and with a stack gas concentration of 7.5 to 8.0 pct SO_2.

Before starting the above series of tests a temperature survey of the fluidized bed was carried out. The results of this survey indicated that temperatures were homogenous throughout the bed except for a narrow zone near the walls of the reactor (see chart).

Copper leaching efficiency of individual size fractions for both overflow and cyclone products is shown in Table V. Copper values are shown concentrated in the coarse and fine fractions. Leach efficiency shows a progressive increase with decreasing grain size. Individual size fraction copper assays and copper distribution of the final decuperized residue are given in Table VI.

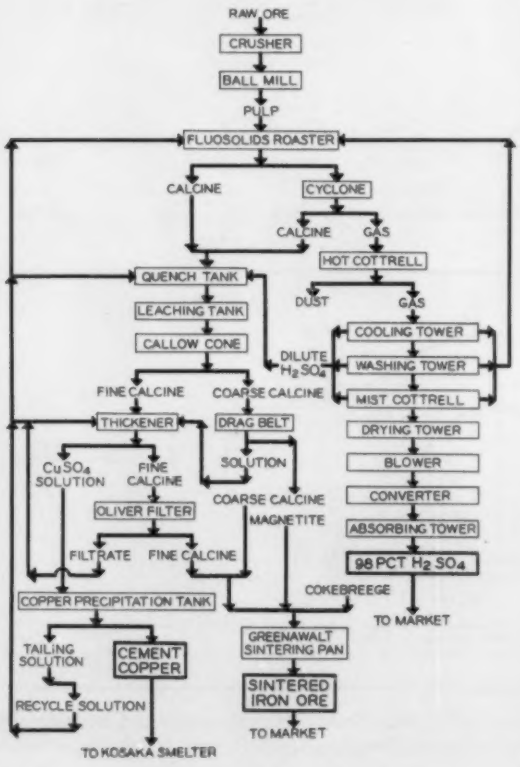
Overflow and cyclone products are collected in quench tanks. Quenching solution is made up of recycle from the copper precipitation tanks plus dilute acid from the gas washing tower.

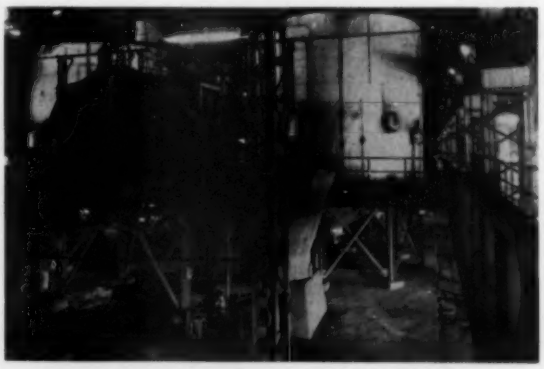
Most of the leaching takes place in the quench tanks but 15 to 20 pct of the copper is leached out in agitators. The slurry from the agitators is classified in a Callow cone. The spigot product is given a two-stage wash in Esparanza-type classifiers while the cone overflow is washed in a two-stage CCD thickener system and dewatered on an Oliver filter. Washing efficiency is 95 pct for the classifier circuit and 95 pct for the thickener-filter circuit. The weight distribution is 30 pct spigot and 70 pct overflow and moistures are 22 pct and 17 pct, respectively.

The pregnant copper solution contains 2.5 gpl Cu, 20 gpl Fe and 5 gpl free H_2SO_4. This solution goes to cementation troughs where the copper is precipitated on scrap iron, aided by compressed-air agitation. The barren solution contains 0.3 gpl Cu, 23 gpl Fe and 4 gpl free H_2SO_4.

A Monsanto contact system is used to produce 98 pct acid. Exhaust gas from the roaster cyclones

OKAYAMA OPERATIONS





FluoSolids roasters and repulper tanks

Ore bedding yard

contains 7.5 to 8.0 pct SO_2, 0.5 to 0.8 pct SO_3, 7 pct O_2 and 11 to 13 grains per cu ft of dust. This gas is cooled to 500°C in the balloon flue before entering the hot Cottrell. From the hot Cottrell the gas passes through a conventional contact plant which consists of gas washing and cooling towers, mist Cottrell, drying tower, blower, converters, and heat exchangers, and goes finally to the absorption tower.

Because of the SO_3 gas produced in the roaster and the cooling action of the flue, a relatively large amount of the iron dust entering the hot Cottrell was sulfated. Shortly after the start of operations it was discovered that the hot Cottrell was not functioning properly because of the build-up of a hard sulfate deposit on the wires. This deposit had grown to as large as 5-in. diam. Because of the resulting inefficient operation, much of the dust went beyond and was collected in the washing and cooling towers. After 11 months of operation these towers became choked with solids and the plant had to be shut down for a clean-out. During the shutdown the wires in the Cottrell were changed from single strand to three strand and a knocking device was added to eliminate the trouble.

Normal sulfur distribution without recycle is given in Table VII. It may be seen from this table that without recycle, the sulphur loss would amount to 22 pct of the total amount. Present sulfur loss of 12 pct is accomplished by recycling a portion of the excess barren solution from the cementation tanks to the FluoSolids reactor in place of water for temperature control (Japanese Patent 196,537). This solution plus some of the solution from the gas cleaning circuit furnishes acid which improves the sulfating efficiency. Copper and iron are recovered from the barren solution and remaining excess solution is oxidized to precipitate the iron, then neutralized with lime and discarded.

The first section of this plant went into operation in September 1953. Rated capacity of the roaster was 115 tpd and product targets were 3000 tons per month of 98 pct H_2SO_4 and 3000 tons per month of 60 pct Fe.

In July 1956 a second FluoSolids reactor of the same capacity was placed in operation. The SO_2 gas from this unit is converted to acid in the original plant which had first been designed for capacity of 200 tpd of 98 pct acid. The leach plant and precipitation section were expanded to handle the increased tonnage. All decuperized residues are sent to Amagasaki Steel for treatment.

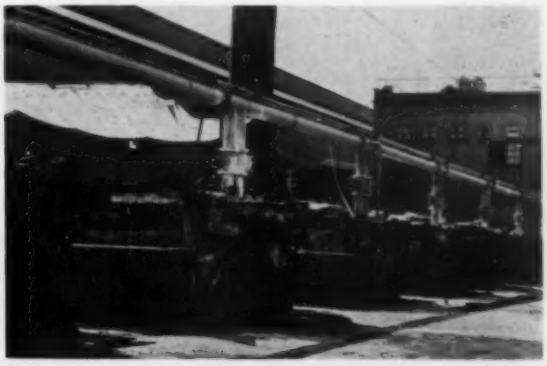
At present, approximate average copper analyses of the feed, calcine, and leach residue are 0.80 pct, 1.00 pct and 0.14 pct, respectively; copper solubility is 85 pct and recovery is 82 pct. Overall iron recovery is 99.0 pct.

The treatment of Yanahara pyrrhotite has been a profitable venture for Dowa Mining Co. In addition to the monetary return obtained from the sale of the copper, sulfuric acid, and iron ore, mining costs on the pyrite have been reduced. By mining both pyrite and pyrrhotite the overall pyrite yield from the mine has increased and, now that pyrrhotite has been converted into ore, the mine reserves have been increased by more than 10 pct. Prospecting has also been simplified and has incidentally led to a new discovery which may total 20 million tons.

REFERENCE

[1] H. Kurushima and S. Tsunoda: Hydrometallurgy of Copper-Zinc Concentrates at the Kosaka Smelter. The Dowa Mining Co., Japan. JOURNAL OF METALS, May 1955.

Ball mill and classifier



Cementation tanks

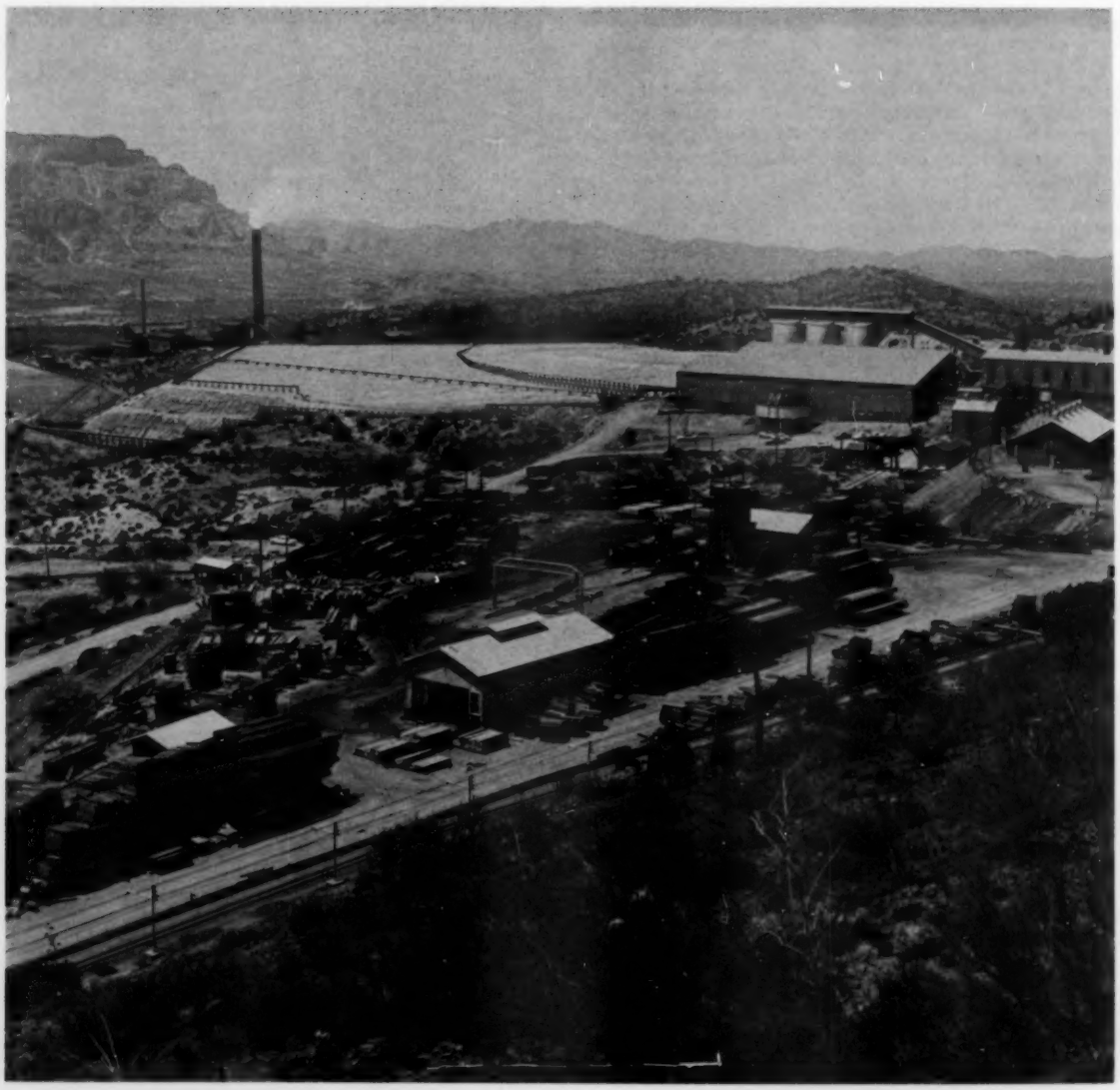
Leaching tanks, thickeners, drag belt

Acid storage tanks

EXPLORATION EXTENDS MAGMA'S FUTURE

by RUSSELL WEBSTER

Magma Copper Co.'s east replacement orebody has a potential little dreamed of a short time ago. If the exploration and development problems can be solved, Magma's productivity may be extended for many more years.



In having maintained production for more than 40 years Arizona's Magma mine is unique in a mineral district that includes several major copper mines. Other past and present producers in this area are Miami and Inspiration at Miami, the Old Dominion in Globe, the Ray mine in Ray, and to the south the new San Manuel mine near Tucson.

Magma's production of copper, silver, gold, and some zinc has come from nearly parallel east-west striking mineralized faults, one called the Main or Magma vein and the other the Koerner vein, about 1100 ft to the south. This vein system has been prospected and partially mined for some 9000 ft horizontally and 4800 ft vertically. In ascending order from the deepest exploration level, the Main vein cuts Pre-Cambrian schist, Pre-Cambrian Apache Group, Post-Devonian diabase, and Devonian, Mississippian, and Pennsylvania limestones. Until 1950 very little ore was obtained from replacement mineralization.

Discovery of Replacement Orebodies: Exploration and mining of replacement mineralization are being carried out in the Devonian limestone in a replacement zone, which occurs 12 to 20 ft above the disconformity between the limestone and the Cambrian quartzite. On surface this zone can be identified by the many prospect holes and inclined shafts, but from surface to the Magma's 2250 level it has produced little ore. In normal exploration and stoping of the Main vein there is a widening of mineralization along this particular zone up to 30 ft north and south of the vein structure. Farther away from the vein this horizon was tested by diamond drilling, but no great amount of mineralization was found.

With continued development of the Main vein to the east a new ventilation shaft was needed to serve this section of the mine. A shaft, designated No. 6, was sunk to the 2550 horizon and connections were made to it by drifting east from the established 2000 and 2550 levels. These drifts followed the Main vein structure to about 900 ft west of No. 6 shaft; at this point the vein was completely cut off by a near vertical north-south fault. The drifts continued through the fault to the connection with the No. 6 shaft.

At the time, the vein-offset on the east side of the fault appeared to be to the south, and subsequent diamond drilling located a vein about 500 ft to the south which seemed to prove this. Additional drilling disclosed that vein mineralization was rather poor, but the replacement zone in the Devonian limestone was strongly mineralized for at least 150 ft (horizontal distance) south of the vein and averaged 15 ft in thickness. This seemingly abrupt change in the amount of replacement mineralization adjacent to the vein indicated a potential orebody, if mineralization and grade continued down the dip of the limestone for a reasonable distance.

The replacement zone is parallel to the 30° east dip of the host limestone.

Next, on the 3000 and 3400 levels, drifts were driven east on the Main vein from the central part of the mine to the intersection with the north-south fault that had first been located on the 2000 and 2550 levels. At the fault the drifts were turned south and driven to the faulted vein segment east of the north-south fault. On each level the replacement horizon was found to be heavily mineralized for at least 100 ft north and 200 ft south of the vein. This showing represented a hitherto uncalculated ore reserve for Magma.

R. WEBSTER is Chief Geologist, Magma Copper Co., Superior, Ariz.

Extension of Replacement Areas: With continued development of replacement beds east of the north-south fault, attention was turned to the west side. There was some doubt as to the true interpretation of movement along this fault. At this time it was still believed that the movement offset the eastern fault segment of the Main vein to the south. If the offset was to the north, however, the newly found vein structure with replacement mineralization could not be the faulted segment of the Main vein but must be a new vein, or possibly the Koerner vein, which lies about 1100 ft south of the Main vein in the central portion of the mine. Exploration was started to locate this unknown vein west of the north-south fault and south of the Main vein.

(*Ed. Note*: General fault movements shown on Fig. 3 have been substantiated by additional information, but there has been an important change in thinking concerning the identity of the vein south of the Main vein. It has been called the Koerner vein but is now indicated to be a south split of the Main vein. Such a split is known and has been mined above the 2000 level but until now has never been considered to be a vein associated with the east replacement orebody.)

The vein structure was successfully located. When it was prospected at the limestone replacement zone, moreover, massive replacement mineralization was found, similar in grade and strike length to the replacement zone east of the north-south fault.

This development was important not only for its possible ore potential but also because it opened for exploration the north faulted Main vein segment (Fig. 3, A) east of the north-south fault and the area to the south, where there may be still other vein structures and possible associated replacement mineralization (Fig. 3, D).

Mineralization: Considered by many to be a textbook example of the zonal theory of vein deposition, mineralization of the Main vein at Magma can be separated into three distinct zones. The upper zone consists of primary zinc and silver minerals down to the 2550 level in the east central portion of the vein. In the middle and lower zones primary chalcocite, bornite, chalcopyrite, and tenanite occur in the upper zone but are more abundant between the 2500 to 3200 levels. At the 3200 level the higher-temperature mineral enargite begins to appear along with bornite, pyrite, and chalcopyrite. Present exploration of the beds indicates that the mineralization of the replaceable bed in the limestone corresponds to middle zone mineralization of the vein.

The general order of abundance is as follows: specularite, pyrite, hematite, chalcopyrite, bornite, chalcocite, quartz, and minor amounts of silver, gold, zinc, lead, magnetite, and barite minerals. The different minerals are generally banded parallel to the 30° east dip of the host limestone. Along with the banding of individual minerals, they also can occur as a massive replacement from foot to hanging wall of the replaced bed. Bornite, chalcopyrite and pyrite have been observed as finely divided particles in specularite and hematite. The chalcocite usually occurs as a banded replacement of bornite, parallel to the limestone banding.

In many instances, study of surrounding wall rock alteration leads to better understanding of an orebody and reveals that its limits can be expanded. A number of headings and diamond drillholes that have cut the limestone underlying the replacement bed at Magma have shown it to be bleached and

Rock Types Associated With the East Replacement Orebody

- **The Troy quartzite** is of Middle Cambrian age with an average thickness of 400 ft and may be quite heavily mineralized when cut by the vein system.

- Overlying the Troy quartzite is the **Upper Devonian Martin limestone**, 350 to 425 ft thick. Underground, the Martin limestone is a dark gray fine grain thin-bedded rock but on the surface it is lighter in color and tends to form debris-covered sloped between the white Escabrosa and the cliff forming Troy quartzite. The lower dolomitic part of the Martin is important economically as a favorable horizon for replacement mineralization in the vicinity of vein cross breaks. It is in this horizon that Magma's east replacement orebody is located.

- **The Escabrosa limestone** is of lower Mississippi age and averages about 420 ft in thickness. It is white to light gray in color. On the surface this limestone has been known to have replacement mineralization, but as yet no ore content has been found underground, although the Escobrosa is considered an area for exploration.

- Of lower Pennsylvania age, **Naco limestone** is a thin bedded white, light gray, or light pink limestone of over 1200-ft thickness. Limited exploration for replacement mineralization has been carried on in this limestone.

- Intrusive as sills in the Troy quartzite, the **diabase** has a total thickness of 3100 ft in the Magma mine. The age of the intrusion is considered to be Post-Devonian.

- A number of dikes of light-colored **quartz monzonite porphyry** cut the diabase, Troy quartzite and the limestones. So far no age relationship between the dikes and replacement mineralization has been established.

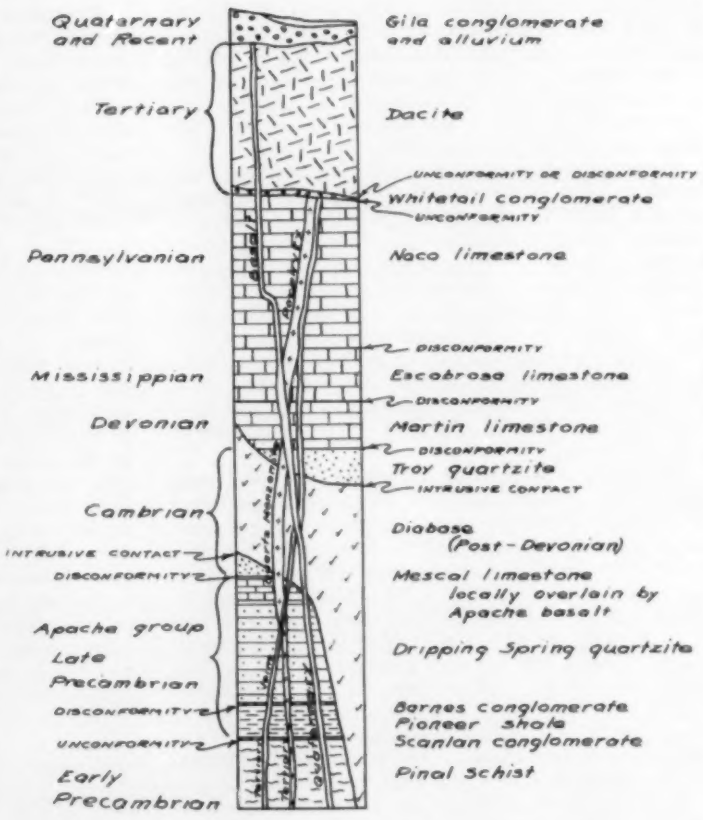


Fig. 1. Generalized geologic column in Magma vicinity. Because of a regional dip of about 30° to the east, the complete stratigraphic column cut by the vein is exposed at the surface near Superior. See Fig. 2.

altered. The hanging wall limestone has less bleaching but has been noted to contain many calcite-filled fractures. More intensive study of this phenomenon may clarify interpretation of data gained from diamond drilling into unknown areas.

Present State of Development: Exploration and development have proved that the beds south of the vein in the replacement orebody are more extensively mineralized than those to the north. Exploration and mining have progressed more than 750 ft south from the vein and about 200 ft north of it. Diamond drilling indicates that down dip the strike length of mineralization in the north bed may be increasing, with a corresponding decrease in the south bed.

The replacement horizon continues below the 3600 level, with mineralization like that in the upper levels. Similar mineralization extends above the 2550 level west of the north-south fault.

Exploration and Mining Methods: Exploration of the replacement bed must be very closely coordinated with mining operations. Owing to an abnormally high rock temperature (125°F) and difficult waste disposal, crosscuts and drifts out of the ore are held to a minimum. Because of this, diamond drilling in fringe areas outside the known ore zone is limited.

From the vein on the footwall of the replacement bed, contour drifts are driven north and south to the ore boundary. From these drifts inclined raises are driven up the footwall of the replacement bed to the ore cut-off or to the next level, a vertical distance of 100 ft. Active stoping of ore starts at the ore cut-off and proceeds down dip at an angle toward the vein. Modified square set timbering in the stopes aids mining and temporarily supports the hanging wall. Because of heavy ground, stopes cave and fill soon after the ore has been removed. To protect unmined blocks of ore, a series of cribs are placed to control this caving.

Ore is slushed from stopes to sublevels, slushed down inclined raises and then goes via ore passes to haulage drifts. Rail haulage takes it to the main hoisting shafts in the central section of the mine.

Located about 2000 ft east of the vein deposits in the central portion of the mine, the east replacement bed can be considered a separate mining unit, with exploration, development, and mining problems peculiar to this area alone. If these problems can be solved, the east replacement orebody will give new life to the long productive Magma mine.

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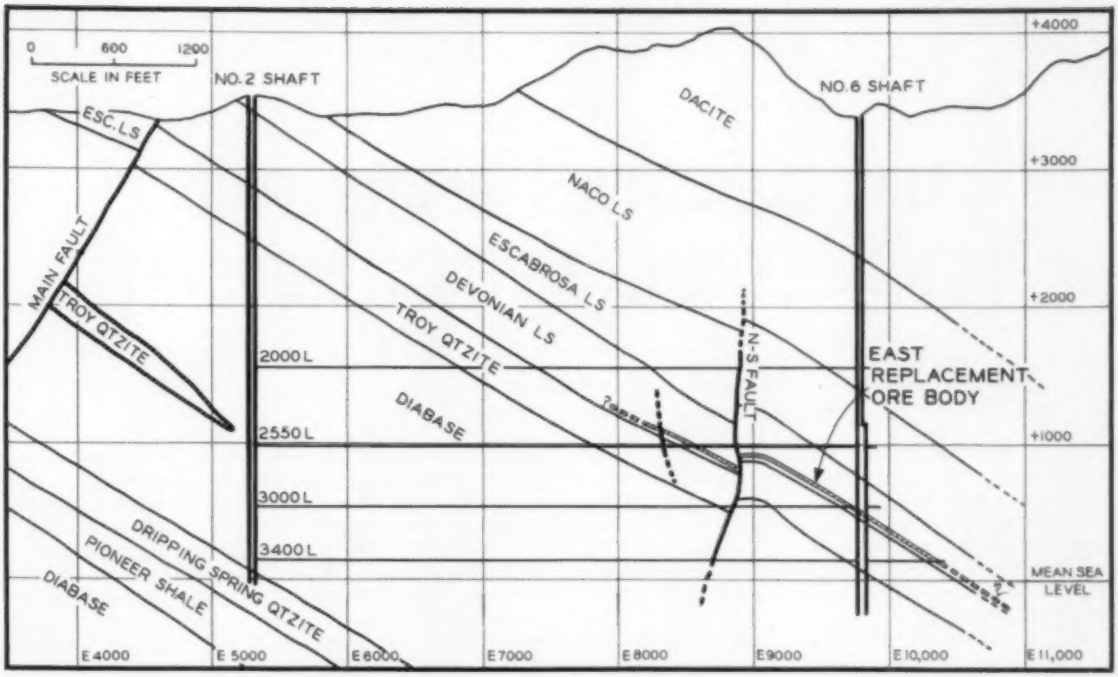
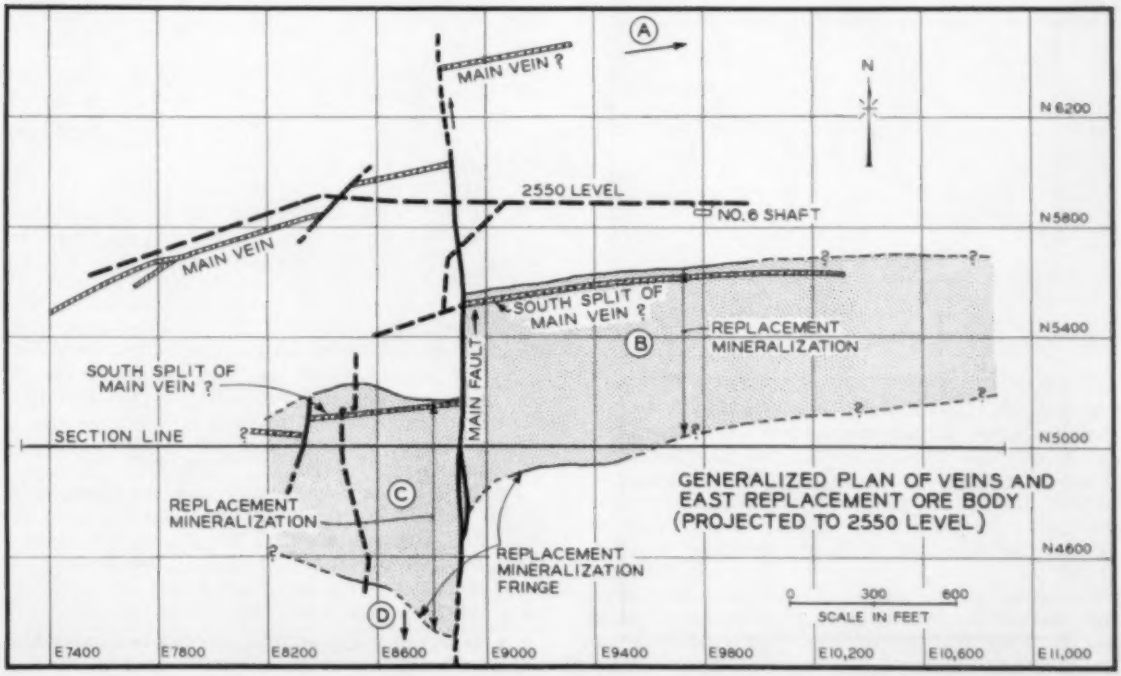


Fig. 2. East Replacement Orebody, east-west vertical section looking north.

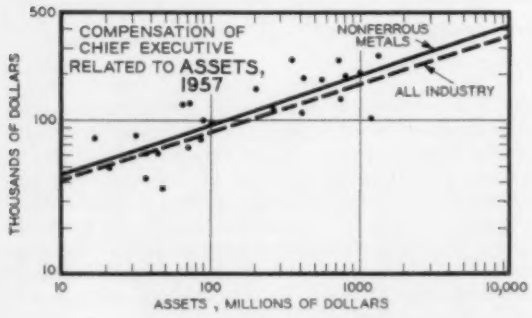
Fig. 3. (A) As far as is known the Main vein has never developed any extensive replacement mineralization when in contact with the Martin limestone replaceable zone. But this condition could change at lower levels to the east and this is considered an area for future exploration. (B) In review of fault movements and vein identities, this vein structure with replacement mineralization east of the north-south fault was located first by assuming that the Main vein was offset to the south. But if the movement was to the north on the east side of the north-south fault then this vein and replacement mineralization (B) had to be an unknown vein. Its counterpart on the west side of the north-south fault was located (C) with similar grade and strike length of replacement mineralization. This vein was considered to be the Koerner vein known from the central section of the mine but new investigations indicate it to be a south split of the Main vein. Assuming this to be true then this would place the Koerner vein and possible associated replacement mineralization further south (D). Thus a new area is open for exploration.

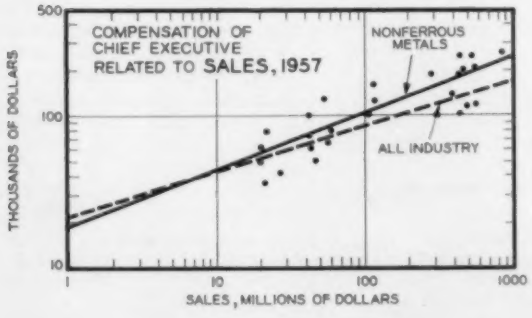


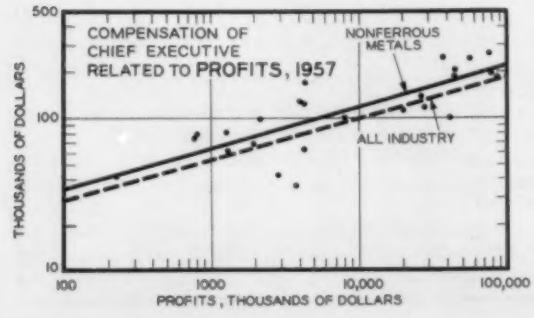
TOP EXECUTIVES HIGHLY PAID IN NONFERROUS METALS INDUSTRY

by S. ROBINSON BRAINARD

• *The following findings result from the fourth annual executive compensation survey recently completed by McKinsey & Co. Inc., management consultants. This survey included over 600 companies listed on the principal stock exchanges, and analyzed compensation patterns in 18 major industries; 26 companies in the nonferrous metals industry were included.*







In 1957 the pay of chief executives in the nonferrous metals industry was well above average when compared with other major industries. Furthermore, it continued to rise last year while sales declined 8.2 pct and profits plummeted 32.7 pct on the average.

Compensation of Chief Executives: One of the primary objectives of the survey is to measure year-to-year changes in top-management total compensation as it relates to company size and industry characteristics. Total compensation includes salary, bonuses, and the value of deferred contingent compensation awards.

The accompanying graphs indicate that compensation of chief executives in the nonferrous metals industry tends to be higher than industry in general when compared with the three important indicators of company size: assets, sales, and profits. Table I bears out the higher than average compensation relative to profits and Table II discloses that, when measured by sales, compensation is at the top of the list for larger companies.

It is interesting to note that the steel and iron industry is also among the top paying industries. On the average it pays its chief executives the same or higher compensation than the nonferrous metals industry at all levels of sales and profits except the $400 million sales level.

Compensation Down the Line: Total compensation of the second highest paid executives in the 26 nonferrous metals companies averages 78 pct of that of the chief executive; the third, 64 pct; and the fourth, 54 pct. This compares with an average for all 18 industries of 69, 57, and 52 pct.

Over the years, studies have indicated that the compensation of subordinate top-level executives is closely linked to the compensation of chief executives and goes up or down according to the pattern set at the top. Since in the nonferrous metals industry not only is the pay of chief executives well above average but the relationship of the compensation of second, third, and fourth executives is also above average (see Table III), it therefore appears that compensation of these subordinate executives is above industry generally when measured by company size factors.

Fringe Benefits: Every company in the nonferrous metals industry sample reported a pension plan in 1957. Five companies out of the 26 showed deductions for profit sharing trusts and 12 companies had stock option or stock purchase plans. In addition, eight companies have awarded either consulting or

S. R. BRAINARD is Associate Consultant with McKinsey & Co., Inc., New York.

Table I. Average Compensation of Chief Executives at Three Profit Levels, 1957

$3 Million		$10 Million		$40 Million	
$102,000	Department stores	$152,000	Department stores	$345,000	Department stores
93,000	Textiles	128,000	Textiles	195,000	Tobacco
87,000	Automotive parts	125,000	Steel and iron	192,000	Steel and iron
86,000	NONFERROUS METALS	122,000	Tobacco	183,000	Textiles
86,000	Steel and iron	119,000	NONFERROUS METALS	180,000	Building materials
85,000	Electrical equipment	115,000	Aircraft	180,000	Aircraft
84,000	Heavy machinery	113,000	Light machinery	171,000	NONFERROUS METALS
84,000	Light machinery	111,000	Retail chains	162,000	Food and beverages
82,000	Tobacco	110,000	Automotive parts	162,000	Retail chains
81,000	Retail chains	109,000	Electrical equipment	160,000	Light machinery
80,000	Aircraft	106,000	Food and beverages	150,000	Chemicals
73,000	Food and beverages	106,000	Heavy machinery	145,000	Automotive parts
71,000	Chemicals	103,000	Building materials	145,000	Electrical equipment
67,000	Railroads	100,000	Chemicals	139,000	Paper and paperboard
66,000	Paper and paperboard	94,000	Paper and paperboard	135,000	Heavy machinery
65,000	Building materials	88,000	Petroleum and Natural gas	120,000	Petroleum and Natural gas
65,000	Petroleum and Natural gas	84,000	Railroads	110,000	Railroads
48,000	Public utilities	64,000	Public utilities	109,000	Public utilities

Table II. Average Compensation of Chief Executives at Three Sales Levels, 1957

$30 Million		$100 Million		$400 Million	
$74,000	Tobacco	$108,000	Steel and iron	$172,000	NONFERROUS METALS
74,000	Electrical equipment	104,000	NONFERROUS METALS	170,000	Steel and iron
73,000	Steel and iron	102,000	Tobacco	160,000	Building materials
68,000	Chemicals	98,000	Chemicals	153,000	Department stores
67,000	Light machinery	97,000	Department stores	152,000	Chemicals
66,000	NONFERROUS METALS	96,000	Building materials	150,000	Tobacco
66,000	Department stores	94,000	Light machinery	139,000	Automotive parts
65,000	Textiles	91,000	Electrical equipment	138,000	Light machinery
65,000	Petroleum and Natural gas	90,000	Automotive parts	131,000	Heavy machinery
63,000	Building materials	90,000	Textiles	131,000	Textiles
62,000	Automotive parts	87,000	Petroleum and Natural gas	130,000	Paper and paperboard
58,000	Heavy machinery	86,000	Heavy machinery	122,000	Petroleum and Natural gas
56,000	Railroads	82,000	Paper and paperboard	119,000	Aircraft
56,000	Paper and paperboard	75,000	Public utilities	119,000	Public utilities
52,000	Retail chain	74,000	Railroads	118,000	Electrical equipment
50,000	Aircraft	74,000	Aircraft	104,000	Food and beverages
48,000	Public utilities	72,000	Retail chains	104,000	Retail chains
43,000	Food and beverages	65,000	Food and beverages	103,000	Railroads

Table III. Median Relationship of Subordinate Executives' Compensation to that of Chief Executives, 1957

Industry	Second Highest Paid Executive, Pct	Third Highest Paid Executive, Pct	Fourth Highest Paid Executive, Pct
NONFERROUS METALS	78	64	54
Paper and paperboard	75	65	56
Tobacco	54	60	49
Petroleum and Natural gas	73	56	50
Chemicals	72	61	57
Electrical equipment	70	60	53
Heavy machinery	69	59	55
Light machinery	69	58	52
Building materials	69	54	43
Textiles	69	58	50
Steel and iron	68	54	50
Food and beverages	67	58	50
Public utilities	63	49	45
Railroads	59	52	50
Retail chains	78	68	58
Automotive parts	68	57	50
Department Stores	78	71	71
Aircraft	78	63	49

Table IV. Changes in Compensation of Chief Executives

1957 Over 1956		1956 Over 1955	
Industry	Average Increase, Pct	Industry	Average Increase, Pct
Tobacco	9.9	NONFERROUS METALS	9.1
NONFERROUS METALS	5.9	Steel and iron	9.0
Aircraft manufacturing	3.6	Public utilities	8.9
Railroads	3.1	Petroleum and Natural gas	6.2
Petroleum and Natural gas	2.6	Heavy machinery	4.8
Public utilities	2.2	Food and beverages	4.4
Electrical equipment	1.6	Railroads	4.3
Food and beverages	0.9	Light machinery	4.2
Chemicals	0.2	Building materials	3.6
Light machinery	(0.1)*	Paper and paperboard	3.2
Heavy machinery	(0.2)*	Chemicals	2.4
Paper and paperboard	(0.2)*	Electrical equipment	2.2
Automotive parts	(1.2)*	Aircraft manufacturing	1.3
Building materials	(1.3)*	Department stores	0.2
Retail chains	(2.9)*	Tobacco	(0.1)*
Steel and iron	(4.3)*	Automotive parts	(1.1)*
Textiles	(5.7)*	Retail chains	(2.4)*
Department stores	(6.5)*	Textiles	(6.0)*

* Decrease.

contingent compensation contracts to executives with payments running for various numbers of years after retirement.

The use of fringe benefits and tax-sheltered compensation devices appears to be somewhat more liberal than in many industries. In many instances, such devices as profit sharing trusts, stock option plans, and deferred contingent compensation contracts offer higher salaried executives either capital gains tax treatment for a portion of their compensation or payments after retirement when presumably their tax bill will be lower.

Year-to-Year Trends: On the average, compensation of chief executives in the nonferrous metals industry has shown a rapid increase over the past three years. In 1956 it was 9.1 pct higher than in 1955, showing the fastest rate of increase of the 18 industries in the survey. In 1957 it was 5.9 pct above 1956, showing the second highest rate of increase. The average percent increase in chief executives' compensation in the 18 industries is shown in Table IV.

The increase in compensation which has made the nonferrous metals industry one of the highest paying industries for top management in 1956 was kept up in 1957 despite a fall in sales and profits.

JACKPILE USES EXTENSIVE BLASTHOLE SAMPLING

by ROBERT B. SCHLOSSER

Anaconda's Jackpile uranium mine is a multi-million-ton open pit sandstone deposit, producing some 3000 tpd for the company mill. With minor exceptions, the orebody is in equilibrium, and the backbone of ore-grade control is the radiometric assay, which fortunately is dependable.

Preparatory Sample Drilling: Before it is stripped, the orebody is diamond-drilled on 200-ft centers N-S and 100-ft centers E-W. Drill core is logged, split, and assayed radiometrically, and several samples are assayed chemically to check the equilibrium status. This information establishes the pit outline and the first rough estimate of ore. After stripping, diamond drill data is supplemented by rotary drillholes on 50-ft centers. Dry chip samples, collected every 2 ft, are prepared and assayed radiometrically at the mine. Details of the orebody are then available for study, and the basic mining plan is drawn up.

Mining: The Jackpile orebody is highly erratic, generally consisting of horizontal beds about 10 ft thick, separated by zones of waste and low grade material that may be up to 40 ft thick. An ore face may be as shallow as 4 ft and occasionally as high as 50 ft. Whether two or three beds are to be mined separately is an economic problem; each situation must be handled individually and changed as the quality of the ore changes.

When blastholes are drilled in the ore preparatory to mining, each hole is sampled and probed with a geiger counter. One crude sample is taken from each hole, from collar to bottom, in a bucket or box that catches part of the cuttings as the hole is drilled. A radiometric assay is determined on this sample. Probe readings are used only as a guide to the depth and lateral extent of the ore bed.

A sketch made by the sampler shows the relative position of the holes, each numbered to correspond with the sample. Assays of the samples are plotted on the blasthole sketch and the various grades of ore in the blast are zoned in the field as depicted on the sketch. The file number of the sketch is then recorded on a master plan map that shows the actual position of this blasthole pattern.

Grade is roughly controlled by placing the shovels in specified zones indicated on the blasthole sketch and then blending the truckloads at the crusher to get the desired grade.

The 44-in. conveyor belt system at the loading station is equipped with a weightometer and microflex counters. When the counters have recorded the predetermined tonnage to the cars, the crusher feeder is automatically shut off, a signal is sent to the time-delay relay, and 10 sec later the conveyor belt is automatically shut off. The next empty car is placed under the chute and a new cycle is started manually.

THE ORE-GRADE CONTROL INSTRUMENT

When the mine was planned, it was hoped that the ore could be blended so that each railroad car could be loaded with approximately the same grade. The first few months of operation in 1956 proved this an impossible task. The next objective was to predict accurately the grade of ore in a group of cars so that the mill operators could blend them as they preferred. Again, failure. Close study of the blasthole sampling technique showed amazing accuracy over a long period, but no accuracy on small parts of the whole. In a given month, estimated grade checked within a couple of thousandths of the percent of U_3O_8 actually shipped. But the ore was extremely spotty, and the smaller the unit that was examined, the worse the comparison became. Some method had to be found to warn the mill of a group of cars containing unusually high grade ore.

In the fall of 1956, the problem was turned over to Eberline Instrument Corp. It was felt that if they could design an instrument which could predict the grade of the ore in a railroad car within 0.05 pct U_3O_8, three-quarters of the time, the industry would have a tremendously useful instrument.

R. B. SCHLOSSER is Production Engineer, Anaconda Co., Laguna, N. M.

In March 1957, Eberline delivered an ore grade control instrument consisting of two major units, a 400-lb monitor and a console.

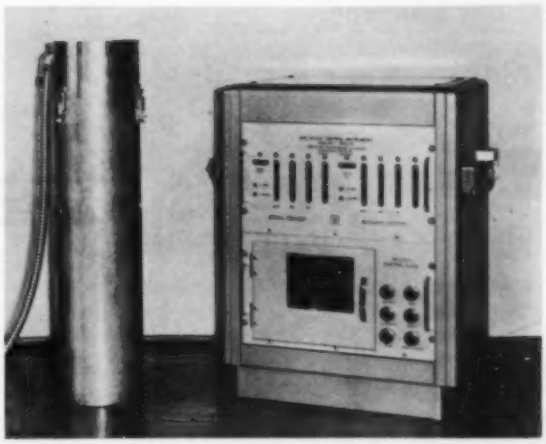
The cylindrical monitor houses the detector (a 2½-in. sodium-iodide crystal), lead shield, temperature stabilizing system, and associated electronic circuitry necessary to pick up, stabilize, and send the signal out to the console over a coaxial cable. The monitor, 8 in. diam and 3 ft high, is mounted on a pedestal under the return-belt side of the conveyor between the crusher and the railroad cars.

The console is in the loading-control shack. It contains the normal and auxiliary counting channels, a printer, and the control panel.

The instrument operates automatically during the loading cycle. When the conveyor belt is started, the counter begins recording impulses received from the detector and an elapsed-time meter starts recording the loading time. When the car is loaded the time-delay relay signals the console, the printer records on a roll of paper the total number of impulses received, and the counters are automatically reset to zero. The elapsed-time meter is read, the loading time determined, and the total number of background counts received during the loading period are calculated. The background count is subtracted from the gross counts received and a net count per carload is recorded.

On the basis of the performance of this instrument during the past year, the following accuracy is expected in future radiometric predictions:

20 pct of predictions within 0.005 pct U_3O_8
60 pct of predictions within 0.01 pct U_3O_8
80 pct of predictions within 0.02 pct U_3O_8
90 pct of predictions within 0.04 pct U_3O_8



Monitor and console of special ore grade instrument.

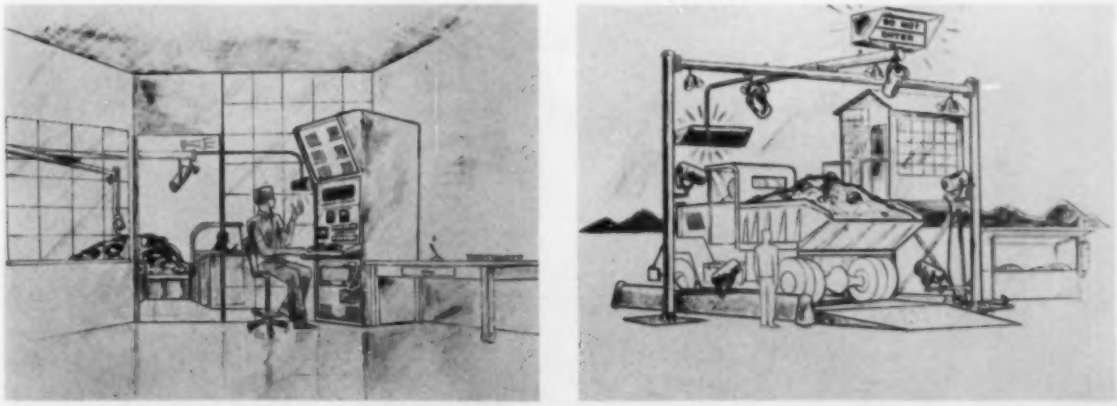
STOCKPILE SELECTIVITY

For every ton of ore mined, 2 to 4 tons of mineralized material must be removed from the ore faces or between the ore faces to strip the lower zones of dilution. Every effort is made to segregate this material in waste or low grade stockpiles of small percent grade tolerances. Each stockpile has a grade range of about 0.03 pct U_3O_8. Every effort is made to avoid placing waste on what may be tomorrow's ore.

The sampling and blasting procedure for low-grade is the same as for the ore faces. If, after the assays of the drillhole samples are studied, an area is found to be of one consistent grade, it is moved in mass to one stockpile. If assays reflect a very spotty condition, each truck load is checked with a probe and geiger counter, and a suitable selection of a stockpile is determined. A grab sample is then taken from the truck so that a constant check on probe control is obtained. There is no positive measure on the accuracy of this work, but all indications are that the bulk of the material is going to the correct stockpile.

PROPOSED CONTROL SYSTEM

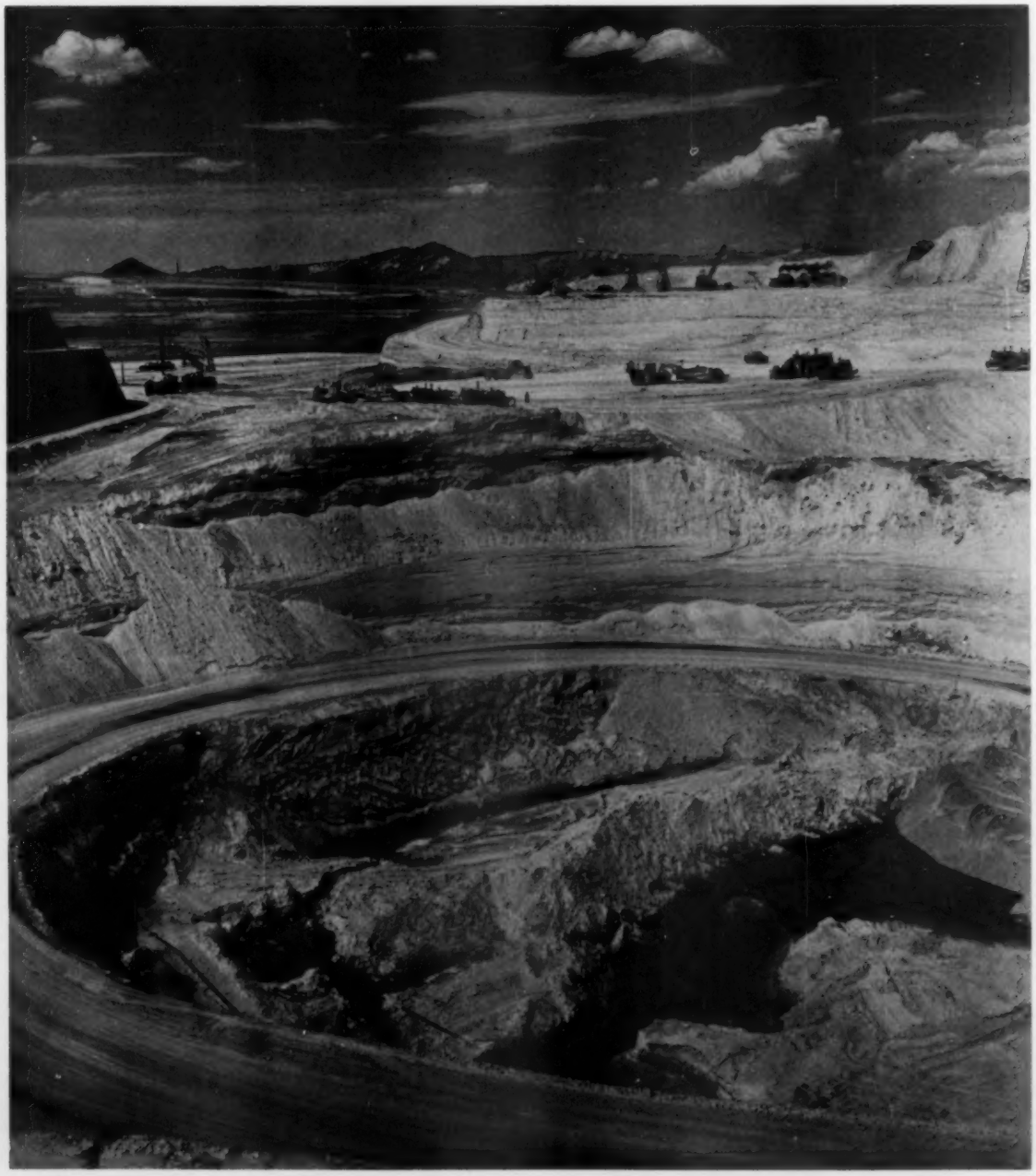
To reduce costs, eliminate the human element, and achieve greater accuracy in stockpile selectivity, Eberline Instrument Corp. has again been consulted. A system is now under construction that this organization designed for the job. As shown in the artist's concept, the design consists of six scintillation detectors mounted about 8 ft from the ramp bed which supports the truck.



When the truck is in position, a 3-sec count is determined. The count from each detector is viewed and recorded with the integrated count. The total count will determine the stockpile to which the load will be sent, and the console operator will signal that stockpile number to the truck driver. A printed record will be furnished to show the individual head count, integrated count, and console operator's choice of stockpile.

LUCKY Mc EMPLOYS ASSAYS, CAREFUL OPEN PIT SLICES

by KEITH G. WALLACE



Small scale open pit mining of the Lucky Mc property in the Gas Hills district of central Wyoming was started in the spring of 1954 and the first uranium ore went to Vitro's mill in Salt Lake City that July. Shortly after mining started it became apparent that accurate ore control for mining purposes would be an absolute requirement. A systematic drilling program was initiated in the spring of 1955, and has been continued up to the present time. Two main mining areas have been developed.

Mine 1, at the site of the original ore discovery in the Gas Hills, covers a mineralized zone roughly 600 x 2800 ft. This orebody was outlined and developed by drill holes on 50-ft centers. Approximately 1300 holes were drilled in the area before preliminary mining plans were made and mineable reserves calculated. Reserve estimates were based almost entirely on chemical assays of drill hole samples.

The Mine 1 orebody is one blanket-like mineralized zone, generally located at or immediately above the water table, with several thin low-grade ore lenses within the zone. Depth of overburden varies from 50 to 80 ft.

Plans called for four pits to be opened up in sequence, from south to north, each pit to be stripped and mined as a separate unit, with the final result to be one continuous pit about half a mile long. Pit wall slopes were designed a maximum 70°, and haulage roads were laid on a grade of 6 pct or less.

The second mining area to be developed, designated Mine 4, is located about a mile south of Mine 1, and covers a series of ore zones extending roughly 600 x 4500 ft.

Mine 4 was drilled on a 100-ft grid pattern and preliminary mining plans were based on data obtained from some 600 drill holes. Unlike Mine 1, radiometric probe results were largely relied upon.

Drilling indicated nine ore horizons distributed irregularly within a stratigraphic zone some 150 ft thick. Ore generally occurs below the water table and overburden above the upper horizon is about 50 to 60 ft. The ore lenses are discontinuous and average about 5 ft thick. Ore grade is variable, with pods of ore averaging +1 pct U_3O_8 not uncommon.

Mine 4 contains the bulk of presently developed reserves. Five pits are planned with maximum wall slopes of 65°, and catch benches provided where deep mining is to be done. Overall pit slopes, including catch benches and haulage roads, are to be 57°. Haulage roads were laid out at maximum grades of 6 pct.

For both Mine 1 and Mine 4, stripping from the surface down to the top of the ore is best done with large equipment. Waste occurring in and immediately above the mineralized horizon requires careful control and is handled with small power shovels and front-end loaders.

Ore reserves were estimated by assigning areas of influence to each drill hole, and certain criteria were set up to serve as calculation guides. For instance, ore grade cutoff was set at 0.10 pct U_3O_8 based on chemical analyses and 0.15 pct based on radiometric results. Also, all assays higher than 1.0 pct U_3O_8 were reduced to 1.0 pct before they were incorporated in ore reserve estimates.

Variable Equilibrium of Ore: In many cases radiometric readings with probes often seem to bear no relationship to chemical assays of samples. This out-of-equilibrium condition, which is particularly evident in Mine 1 ore, results in a different ore control problem.

Mine 1 ore presumably is not in equilibrium because its position at or near the water table allows continual leaching and redeposition of certain uranium minerals within the ore zone. Resulting unreliability of radiometric assays in Mine 1 has resulted in almost complete reliance upon chemical assays for control. However, equilibrium contour maps, showing areas of equal disequilibrium, have been helpful in the pit grading of ores with radiometric probes.

Probe results in Mine 4, while not completely reliable, are usually accurate enough to be used for reserve calculations and mine control purposes if frequent correlations are made with chemical analyses.

A recently installed beta-gamma scaler has been valuable in giving rapid radiometric U_3O_8 determinations on ores that are out of equilibrium. Studies are being continued for a satisfactory method of interpreting radiometric data in terms of U_3O_8 content.

Drill Sampling: Three methods have been successfully used for obtaining ore samples: dry rotary drilling, *rat hole* drilling, and frozen core diamond drilling.

Dry rotary drilling is considerably more economical than the other two methods, but its use is limited to areas above the water table if samples are to be obtained. A dust collecting system fabricated at the mine is used to assure maximum sample recovery, and samples collected from dry rotary drilling have proved very reliable.

Rat hole drilling, essentially an auger-bucket method providing positive sample retention, is used to drill holes from 10 to about 28 in. diam. While slower and more expensive than dry rotary drilling, this method has been valuable in drilling wet areas for bulk or extremely accurate samples. Its drawback is that it is ineffectual in hard ground.

Frozen core diamond drilling has been one of the most useful exploration tools. As developed and practiced at the Lucky Mc mine, the method involves circulation of diesel fuel that has been chilled with dry ice. In most cases it has resulted in nearly complete core recovery in wet, unconsolidated ground that is virtually impossible to sample by other drilling methods. The method is costly, but where the depth to ore is known it is possible to plug drill to within several feet of the zone to be cored and thereby considerably reduce costs.

Mine Control Drilling: After pre-mine stripping is completed, mine control drilling accurately outlines the ore. Short vertical holes, spaced on 35-ft centers, are drilled through the ore horizon and in fringe areas supplemental holes are often drilled between the regular spacing. In Mine 1 control drilling, samples are collected for each 1-ft interval and chemically assayed. Probe results are generally satisfactory in Mine 4 control drilling. Detailed mining plans are formulated from the results of this drilling.

Erratic characteristics of the ore were proven when mine control drilling had been done and actual mining started. Ore lenses that appeared to have reasonable continuity on paper turned out to have little continuity in the ground. Pinching, swelling, plunging, and splitting of the ore lenses, as

K. G. WALLACE is Assistant to the Vice President, Utah Construction Co., Palo Alto, Calif.

Pre-mine stripping with scrapers in Mine 4 area. Dry rotary drilling to outline ore horizons—right foreground.

Pre-mine stripping completed, waste and ore is being selectively mined by shovel in this pit in the Mine 4 area.

well as unpredictable uranium values, are common to both mines. It quickly became evident that extremely selective mining would be necessary for maximum ore recovery with minimum dilution. Results so far have been gratifying.

Pit planning is a never ending process at Lucky Mc. Continual revisions of mine plans are made to take advantage of information obtained from check drilling in fringe areas and also to apply valuable experience from the mining operation. Effective pit planning is particularly important because stripping ratios are high—exceeding 30 cu yd of waste to each ton of ore in some deep areas yet to be mined.

Difficulties in Mine 1: Mine 1 ore is lower in grade than Mine 4's and the difference between ore and sub-marginal ore is only a few hundredths of a percent U_3O_8. As a result there is small room for error in pit grading. Visual ore control is rarely possible, and as mentioned, probe results are generally unreliable. Finally, individual lenses of ore are thin and in places alternating bands of ore and waste may occur within a limited vertical range.

Two mining systems have been used in Mine 1. In both, the ore intercepts determined in mine control drilling are relied upon for vertical control.

In the first system, waste and ore are removed in turn by horizontal slices over the entire mining area, but this is not entirely satisfactory since top and bottom of the ore are undulating surfaces.

In the second, more effective system, the area to be mined is stripped to the highest points of the ore horizon, and mining is then started by making parallel slices—not necessarily horizontal—along section lines or at right angles to the sections, whichever gives easier access. In this way an attempt is made to follow major undulations of the ore zones, and successive layers of ore, low-grade ore, or waste may be separately removed in convenient thicknesses.

Both radiometric and visual control are generally possible in the Mine 4 area. Visual control is based on both the color and texture of the rock and proves quite helpful when augmented by probing. Ore grade is considerably higher than in Mine 1, and ore boundaries are well defined. Comparatively little marginal ore is encountered, and mining results to date have been extremely encouraging.

Stockpiles: It has been found advantageous to set up three general types of stockpiles. A probe tower is located in each pit, and the probe operator determines the destination of each truckload of material (excluding pre-mine stripping) before it leaves the pit. When there is little question but that a load is ore, it is directed to the mill and placed, according to estimated grade, in blending piles. When it is not clear that a load is ore, the truck is sent to a stockpile area where each load is dumped separately in windows. Later, after sampling and assaying, it may be reclaimed and sent to the mill. If a truckload is clearly submarginal it is directed to a third area for possible future treatment.

Pre-mine stripping of the first pits to be opened up in both Mine 1 and Mine 4 was started in the spring of 1957. Over 400,000 cu yd of overburden were stripped from Mine 1 with a 2½-yd shovel, and about 1,400,000 cu yd were stripped from Mine 4 with five 26-yd scrapers.

Limited mining was done through much of the past winter to make a sufficient stockpile of ore available for the start of milling last spring. Additional stripping and mining equipment has been acquired in 1958. The supervisory and engineering staff has been enlarged, and the operating and maintenance crews have been greatly expanded. Approximately 160 men are now employed in the mining operations.

Major items of equipment on the pre-mine stripping phase of the operation are:

26-yd tractor-scraper units (5)
21-yd tractor-scraper units (5)
2½-yd diesel shovel
15-yd end dump trucks (4)
8-yd end dump trucks (2)
Crawler-mounted tractors (8)
Motor graders (2)

Most of the pre-mine stripping is readily moved by the scrapers, but rippers mounted on crawler tractors are often used to prepare the ground. Scraper loading requires two crawler tractors pushing in tandem. Time studies of two types of large rubber-tired push tractors, one of them a new 52-ton machine, were completed at Lucky Mc in April.

Our tentative conclusion is that such equipment may decrease the loading time and have considerable cost advantage over conventional crawler mounted pushers for our type of stripping.

Mining and mine stripping is accomplished with the following equipment:

1½-yd shovels (2)
3-yd track-mounted front end loader
2¼-yd track-mounted front end loader
8-yd end dump trucks (12)
Crawler tractor with dozer
Motor grader

The 2½-yd shovel is generally used in areas that are too restricted for efficient scraper operation, and in areas where rock is harder than average. Drilling and blasting are sometimes necessary, and light shooting is commonly used to speed digging.

Additional trucks, when required, are rented locally. Because of their mobility and ability to work in tight quarters, the track-mounted front end loaders have been very effective in mining.

With present mine organization and equipment it is planned to strip over 5 million cu yd this year and mine enough ore to build sizeable ore stockpiles, in addition to supplying current mill needs.

Wyoming Uranium and The Lucky Mc

The Gas Hills District, in the four and a half years since the initial uranium discovery was made, has become the hub of one of the most important uranium-producing areas in the country—the central Wyoming uranium region of some 10,000 sq miles. Embracing about 200 sq miles, the Gas Hills contain the state's largest developed ore reserves.

Much of the ore discovered and developed in the Gas Hills is relatively shallow, and virtually all production is from open pits. The ore bodies were possibly formed as the result of leaching of uranium from surrounding intrusive or volcanic rocks by ground waters, followed by deposition in and along stream channels in receptive areas of the host formation, the Wind River. The ore occurs in long, sinuous, channel-like configurations, generally in medium to coarse-grained, loosely consolidated sandstone. Uraniferous conglomerates, siltstones and carbonaceous shales are also sometimes found. Average ore grade at most properties is probably between 0.15 and 0.35 pct U_3O_8. Most abundant of the many ore types found is uraninite.

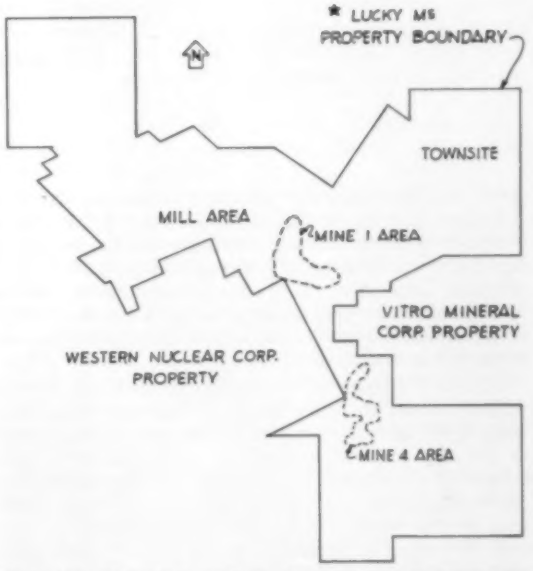
In the Gas Hills district, major known reserves are controlled by six companies: Lucky Mc, Western Nuclear Corp., Globe Mining Co., Federal Uranium Corp., Vitro Minerals Corp., and Union Carbide Nuclear Co.

Wyoming's first commercial discovery was made by Neil McNeice in the autumn of 1953. Mr. McNeice and partners founded the Lucky Mc Corp. to develop and mine the area and called upon the New Park Mining Co. for assistance.

During 1955 it became apparent that substantial ore reserves occurred on the Lucky Mc property, and a mill to treat the ores might be justified. Utah Construction Company was asked, in exchange for a controlling interest in the corporation, to explore the property and develop a sufficient tonnage of ore to justify a mill proposal, negotiate a milling contract with the AEC, secure financing, and design and construct the needed facilities. The company accepted and both the mine and mill are now in operation.

In the Crooks Gap area, some 25 miles south of the Gas Hills, two companies hold most of the known ore reserves: Green Mountain Uranium Corp. and Continental Uranium Co. Both underground and open pit methods are used, but here the emphasis is on underground mining.

Most Wyoming mines use scrapers to strip down to the ore zones, and the ore is mined with small shovels or front end loaders. One operator uses drag-



lines for stripping, and at some mines scrapers are employed for actual mining.

As the state is one of the newest uranium areas to be developed, only 1650 tpd of milling capacity had been authorized by the AEC prior to the freeze, in late 1957, on additional capacity.

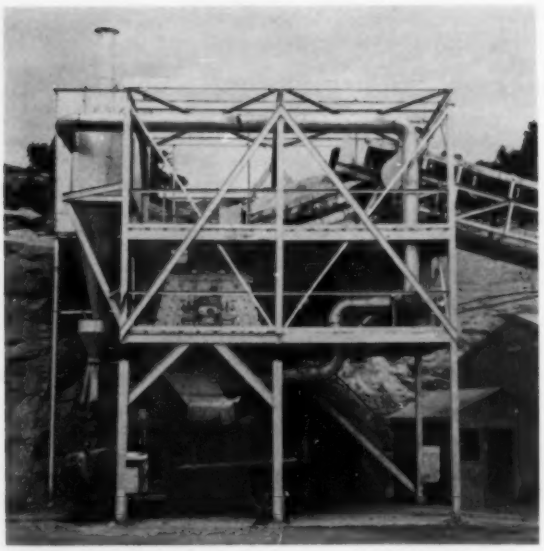
Recently, however, the AEC announced that of a total of 3300 tons of newly authorized daily milling capacity, about 1700 tons will be allocated to Wyoming. This will bring the rated capacity of Wyoming mills up to 3350 tpd.

There are at present two uranium mills in operation in Wyoming and construction of a third is underway. First in production was Western Nuclear Corp.'s mill north of Crooks Gap, which started operations in July 1957. This mill, rated at 400 tpd of ore, utilizes acid leach and resin-in-pulp circuits. The second mill, the Lucky Mc, commenced operations in February 1958. Employing acid leach and moving bed column ion exchange circuits, the Lucky Mc mill has a rated capacity of 750 tpd. Fremont Minerals is constructing a 500-tpd custom mill which will incorporate both acid leach and carbonate leach circuits in processing the large variety of custom ores the company will purchase.

At the end of 1957, the AEC placed Wyoming's ore reserves at 9.2 million tons with an average grade of 0.26 pct U_3O_8, ranking the state second to New Mexico in total reserves.

BLENDING CONTROL AT CORD MINE

by S. E. CRAIG



Jen Inc., operator of the Cord mine, in the Big Indian district of San Juan County, Utah, has a contract with a milling company that provides a small bonus for proper grading and preparation of uranium ores shipped. To obtain maximum returns on this contract very close grading is required with settlements made on individual lots, which vary from 250 to 300 tons.

Another feature of the contract, and one that is rather unique in this country, is that the ore is sold over truck scales at the mine. Grade is determined at the buyer's sample plant. It is necessary to take a moisture sample of each truckload shipped for accurate weighing and this is done by the representative of the buyer, using facilities supplied by Jen Inc. The sample is hardly more than a grab sample and includes only the finer and smaller pieces of the ore shipped.

The ore mined is soft mudstone and hard arkose sandstone. The sandstone breaks in large boulders when pillars are being removed and though it contains 0 to 1.5 pct inherent moisture, it seldom gets into the moisture sample. The samples usually run somewhat in excess of 5 pct. The mudstone, which usually breaks fine, carries about 4 pct moisture and also picks up most of the drilling water.

For the purpose of grading and for obtaining an accurate moisture sample it appeared advisable to crush the ore. The buyer has a 10-in. grid for a grizzly and it was almost impossible to break up the hard arkose sandstone boulders to pass through it.

The crusher installed is a Holland 25 x 20 in. unit fed by a 36-in. conveyor belt 80 ft long. Before entering the crusher the ore passes over a Ty-Rock vibrating screen where 2 in. material is removed. The conveyor belt is fed from a small pocket at the mine shaft. Undersize from the screen and the crushed product from the crusher fall directly into a truck. The belt feeding the crusher may be controlled by the crusher operator or by the truck driver; each has a switch convenient to his location. Signal lights indicate to truck driver, crusher operator, and hoistman when the belt is stopped.

S. E. CRAIG is Assistant to the President, Jen Inc., Moab, Utah.

The impact breaker reduces the ore to −2½ in. in a single pass, and crushed rock plus fines from the screen are perhaps 75 pct −1 in. mesh. A cyclone and baghouse are used to collect dust.

Ore from the crusher is stockpiled by grade into various piles, the truck driver stopping the conveyor belt while he dumps his truck. Hoisting meanwhile continues because there is room for several skips in the shaft bin.

Approximately a dozen ore areas are being worked in the Cord mine and grade varies greatly but is fairly uniform within an area. Both muck pile and mine car samples are taken daily and the use of geiger counters with 32-in. probes is invaluable in keeping track of any change of grade.

Haulage crews usually work a single area or several areas of similar grade. The ore is hoisted in much the same order as trammed and the skip tender advises the crusher operator whenever he changes ore. Thus, from information previously supplied by the superintendent, the probable pile on which the ore is to be stored is known. Final determination is made by the truck driver who uses a geiger counter to probe each truckload of crushed ore. Five stockpiles are being built as follows:

1) 0.15 pct U_3O_8
2) 0.15 to 0.30 pct
3) 0.30 to 0.50 pct
4) 0.50 to 0.80 pct
5) +0.80 pct

The crusher has been in operation only a short time but, aside from its value for grade control, it appears able to pay its way in more accurate samples and in reducing moisture in ore shipped by ½ or ¾ pct. Calculating the larger reduction on a 10,000-ton monthly shipment, this amounts to 75 tons of ore per month. If this ore has a value of $50 per ton saving amounts to $3750 per month or 37¢ per ton of ore crushed. It is estimated that crushing expense will be 15¢ per ton.

The value of properly marketing ore must not be underestimated. A superintendent will spend a great deal of time and effort to lower his powder cost a dime a ton or any other cost a few cents; so it is well that we look to grading and blending—there may be two bits there.

GOOD PRACTICE IN URANIUM ORE SAMPLING

Adequate control requires good sampling. Use this data as a guide to the four major steps in general practice.

by GILMAN C. RITTER

Moisture sampling of uranium ore should coincide as nearly as possible with weighing of the lot represented by the sample. This requires care by the sampler since the sample must usually be taken as a grab from each truckload as dumped.

Correct proportions of coarse and fine material are necessary. A sample of at least 10 lb should be collected, placed in an air tight container, and promptly taken to the moisture determination room. Further, the sample should be dried for a minimum of 24 hr or until there is no further apparent loss of weight at a temperature no greater than 110°C.

Size Reduction: Minus ¼ in. has been found most desirable as the final sample product size. Most sampling plants employ three-stage crushing, mechanically cut a sample following each crushing stage.

Sample Cutting: Because an ore stream passing through a sampling plant will vary both longitudinally and in cross section the sample cutter should take the whole of the stream a portion of the time, rather than a portion of the stream all the time. This requirement precludes use of most stationary types of sampling devices.

The cutter must travel at a uniform rate and be adjusted to pass completely through and out of the ore stream during each cut; it also must travel at right angles to the ore stream. The opening between the cutting edges should be at least four times the diameter of the largest particle size.

Minimum sample size for a small lot is 100 lb. Two lb of sample per ton of ore is the minimum acceptable for larger lots. Three-stage sampling taking successive cuts of 20 pct, 10 pct, and 5 pct (or three cuts of 10 pct) will result in 2 lb of sample per ton. Capacity of buckets or scoops must be great enough to prevent spillage and the cutter should travel slowly enough to keep particles from discharging by centrifugal force—as in the case of rotary samplers—or from knocking particles out of the ore stream. For rotary type cutters such as the Vezin, 25 rpm is considered near-maximum speed; cross-flight buckets are found effective at 18 to 20 cuts per min.

Properly aligned and maintained, the Vezin, Snyder, and cross-flight buckets fulfill basic requirements and are now most widely used.

Surge bins or vibrating feeders etc., should be used to keep feed to the cutter as constant as possible. All chutes and bins must be tight and constructed to allow rapid and thorough cleaning to avoid contaminating succeeding samples.

G. C. RITTER is Chief, Ore Procurement Branch, Source Material Procurement Division, Grand Junction Operations Office, U. S. Atomic Energy Commission, Grand Junction, Colo.

Sample Preparation: A Jones riffle may be used to reduce the final sample to 100 lb. The material should then be mixed 12 to 20 min in a mechanical blender and dried sufficiently for crushing to 10 mesh. After the crushed material has again been thoroughly mixed, a 10-lb sample must be cut with a Jones riffle.

This sample should be dried, if necessary pulverized −28 mesh, and then blended 15 to 20 min in a mechanical blender.

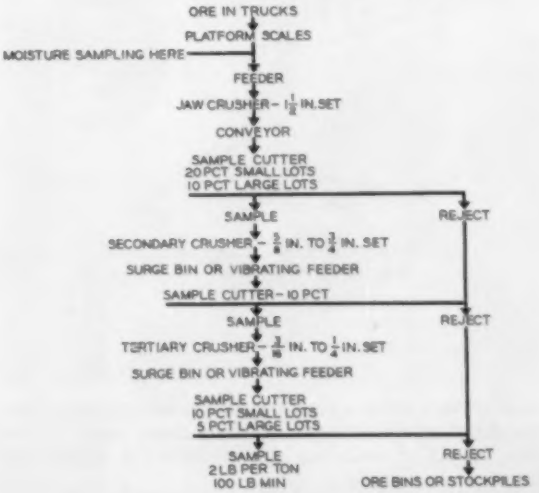
From this a 2-lb sample should be taken with a Jones riffle and pulverized −120 mesh.

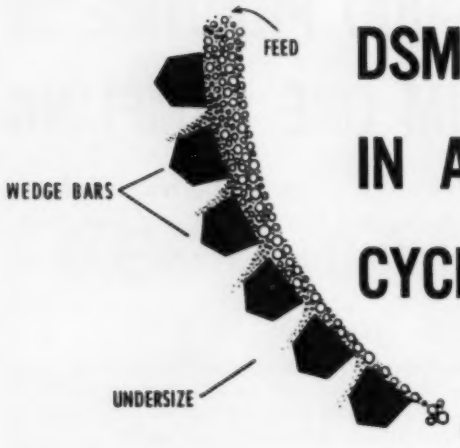
Finally, this should be mixed by rolling or blending before splitting into the required number of sample pulps.

Problems: Mechanical inaccuracies may be traced to improper alignment of cutting devices, worn cutting edges, improperly leveled ore stream, or excess cutter speeds. Improper particle sizing through use of worn screens and contamination or loss of sample through badly worn chutes or bins are other factors.

Errors attributable to the human element include poor moisture sampling, failure to clean sampling equipment between samples, and improper use of laboratory equipment. Failure to thoroughly mix the final mechanical sample before sample preparation begins, and insufficient blending time prior to laboratory splits also contribute to inaccuracies. These inconsistencies can only be corrected through the use of trained, conscientious personnel.

HYPOTHETICAL SAMPLING PLANT



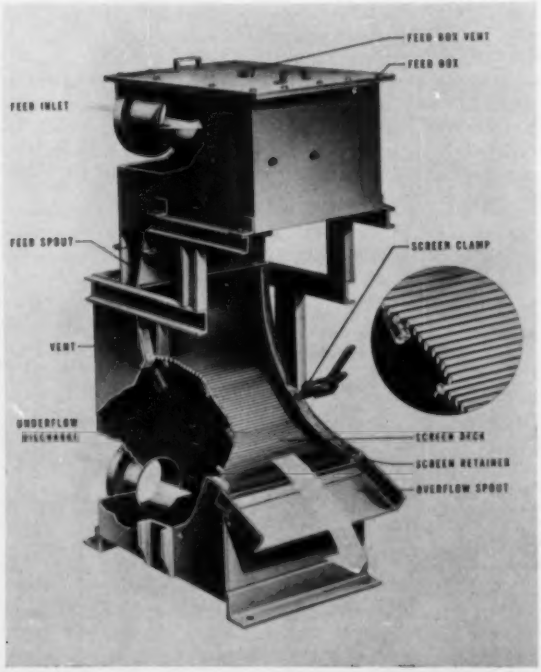


DSM SCREENS IN A HEAVY-MEDIA CYCLONE PLANT

by WILLIAM R. VAN SLYKE, JAMES STUKEL, and LEON KELLER

Two 4-ft wide DSM screens were installed during 1957 in one unit of the two-unit heavy media cyclone section of the Holman-Cliffs concentrator at Taconite, Minn., following successful laboratory test work on a 1-ft screen. The two screens materially reduced the amount of media sent to the magnetic separator cleaning circuit. Wear life was good and fine size capacity was high.

W. R. VAN SLYKE and J. STUKEL are, respectively, Range Metallurgist and Operating Metallurgist, Cleveland-Cliffs Iron Co., Taconite, Minn. L. D. KELLER is Sales Engineer, Dorr-Oliver Inc., Stamford, Conn.



Dorr-Oliver's DSM screen. *See illustration adjoining title for detail of screen deck. As feed slurry passes across bars, layers of undersize are continuously shaved off leaving oversize solids.*

Briefly, the Holman-Cliffs heavy media cyclone plant uses −65 mesh magnetite as media and 10-in. diam., 30° Ni-Hard cyclones as separatory vessels. Feed to the plant averages 130 long tons per hr of −⅛ in. +65 mesh material. The conventional heavy media circuit uses drum or spiral type separatory units and treats +⅛ or 3/16-in. material. The medium is generally −65 mesh ferrosilicon. Ore and media are readily separated by screening at about 6 mesh. At this size, capacity is high and wear and maintenance are not excessive. The heavy media cyclone plant requires an efficient separation between +65 mesh ore and −65 mesh media. To reduce costs, however, the separation was made at a coarser size with the result that the media was unduly contaminated and it was necessary to clean large tonnages of media and ore in magnetic separators. Due to the high capital cost of these units, their number was kept to a minimum and, consequently, they were overloaded. As a result, the separation between magnetic media and nonmagnetics was not sharp and the magnetite losses were high.

The DSM screen, which offered an economical means of separating the +65 mesh ore from the −65 mesh media, is an original development of the Coal Preparation Div., Mining Research Establishment, Dutch State Mines, the Netherlands. Since 1954 Dorr-Oliver Inc. has been actively engaged in the development, design, and possible commercial applications of the screen.

The unit consists of a concave wedge bar type screen in a stationary housing provided with a feed spout, oversize, and undersize collectors. High capacity is achieved without any moving parts. The opening between the bars is approximately twice the mesh of separation and provisions are made to reverse the screen surface to equalize wear.

Operation: In this installation one screen was equipped with a 0.5 mm deck and gave about 65

to 100 mesh separation; the other, with a 0.7 mm deck, gave about 48 to 65 mesh separation. Most of the screen undersize was returned to the circulating media sump (cyclone feed pump) and the balance was sent to the thickener for water removal and gravity control. Oversize was sent to a 6 x 12-ft single deck vibrating screen for washing attached media from the gangue.

Results: The screen equipped with the 0.5 mm deck was operated for 1124 hr and the 0.7 mm deck was operated for 890 hr. Both decks appeared to be badly worn by the end of the operating season but were still giving satisfactory results even though future life was probably limited. Tables I and II show the results of the test work.

The amount of float media which had been reclaimed by primary magnetic separators in the unit containing DSM Screens (see Table I) was 24.8 to 34.2 pct of that reclaimed in the conventional unit. The greater amount in the latter was necessary to keep contamination of the circulating medium within operable limits.

It can be seen from Table II that primary float magnetic separator losses have been reduced 86 pct by use of the DSM Screen. One would expect that secondary magnetic separator losses would be reduced proportionately. However, other components, such as wash screen and tramp screen oversize, also formed a part of the secondary magnetic separator feed; hence, this proportion was not carried through into the final magnetic separator tailings.

It is interesting to note the actual media losses by inventory. About half the operating season was completed before the DSM screens were installed in one of the two units. The overall media losses by inventory (both units) for the last half of the season were 25 pct less than the first half. It would probably not be correct to assume that losses would be reduced 50 pct if DSM screens were installed in the other unit—due to differences in the efficiency of the secondary float magnetic separators—but it is evident that the screens did reduce magnetite losses substantially.

Magnetic Separator Concentrate: Surprisingly, although considerably less feed was sent to the magnetic separators in the DSM circuit the magnetic separator concentrate was not as clean, percentagewise, as from the non-DSM circuit. However, the DSM circuit offered a two to threefold reduction in the nonmagnetic tonnage contained in the float magnetic separator concentrate. It is believed that the performance of the individual magnetic separators may be responsible for some of the apparent discrepancy in the following data as they pertain to the quality of the magnetic concentrate:

	DSM Unit 0.5 mm Deck	0.7 mm Deck	Conventional Unit 0.75 mm Deck
Dry Magnetic Separator Conc., Ltph.	21.4	15.5	62.5
+48 mesh in Magnetic Separator Conc., pct.	16.37	18.54	8.41
Magnetic in +48 mesh, pct.	2.89	0.75	1.92
−48 mesh in Magnetic Separator Conc., pct.	83.63	81.46	91.59
Magnetic in −48 mesh, pct.	89.73	91.06	90.63
Total Magnetics, pct.	75.85	76.26	83.17
Nonmagnetics in Separator Conc., Ltph.	5.2	3.7	10.5

Cyclone overflow, containing magnetite and cyclone rejects, formed the feed to the DSM units and to the vibrating screen on the sister unit. Due to the fact that these units were operating in parallel, the DSM screen feed is considered equal to the vibrating screen feed (see Table III).

With the exception of quantities of pulp caused by a different number of cyclones to each screen, it can be seen in Table III that screen feeds were practically identical in character.

DSM Screen Undersize: Float-drain undersize was returned to the cyclone circuit uncleaned and it was of importance that this material was as high in magnetics as possible (see Table IV).

Since the magnetite medium was essentially −65 mesh, the +65 material roughly equaled the nonmagnetic content. Ten to 12 pct more magnetics were found in DSM screen undersize. Because float-drain screen undersize tonnage is high, a small increase or decrease is of considerable importance in cyclone plant operation.

DSM Screen Oversize: The float-drain screen oversize was washed, and the wash screen oversize rejected—if magnetite content was not too high—or sent to the secondary magnetic separators to remove more of the adhering magnetite (see Table V). Plant arrangement prohibited satisfactory sampling of vibrating drain screen oversize.

The merit of the DSM screen is its ability to produce a fine, clean screen undersize at high capacities. The oversize, however, contained considerable undersize and this could no doubt be reduced by repulping the oversize and passing it over another DSM unit in series, if head room would permit. Process permitting, it is probable that dilution water in the feed would also reduce the amount of undersize in the oversize.

Variation of Performance with Deck Wear: It was mentioned previously that the 0.5 mm deck ran

Table I. Reduction in Amount of Float Media Cleaned

	Magnetic Separator Concentrate, Ltph DSM Unit		Magnetic Separator Concentrate, Ltph Conventional Screen
	0.5-Mm Deck	0.7-Mm Deck	
High	39.4	19.7	80.0
Low	10.7	10.9	44.4
Average (14 tests)	21.4	15.5	62.5

Flow Conditions:

Screen Feed	55 to 89 gpm of pulp per ft of screen width
Feed, percent solids	67 to 73 pct by weight
Magnetics, pct	70 to 86 pct
Pulp feed rate	35 to 40 Ltph per ft of width
Dry solids, feed rate	19.5 to 37.3 Ltph per ft of width (ore and medium)

Table II. Primary Magnetic Separator Losses in Grams of Magnetite Per Gallon of Magnetic Separator Tailings

	DSM Unit		Conventional Screen Unit	
	Mag. Sep. No. 1	Mag. Sep. No. 2	Mag. Sep. No. 1	Mag. Sep. No. 2
High	3.162	4.786	24.625	26.537
Low	0.353	0.297	6.620	3.991
Average (9 tests)	1.553	2.066	15.932	11.254
Average, No. 1 and 2 separators	1.809		13.593	

Table III. Nature of Cyclone Overflow

	DSM Screen Feed	
	0.5 Mm Deck	0.7 Mm Deck
Magnetics, pct		
High	86.76	87.63
Low	70.48	70.48
Average	80.60	80.44
Solids, pct		
High	73.57	73.83
Low	67.85	68.26
Average	71.30	71.71
+65 mesh, pct		
High	12.59	13.46
Low	5.44	8.50
Average	10.17	10.47
−100 mesh, pct		
High	91.11	89.75
Low	83.06	82.30
Average	86.43	86.02
Average Feed, Ltph*	158	130
Average Pulp Density	2.30	2.33

* Overflow from 3 cyclones to 0.5 mm deck; 2 cyclones to 0.7 mm deck.

Table IV. DSM & Vibrating Screen Undersize Compared

	DSM Screen Undersize		Conventional Vibrating Screen Undersize
	0.5 Mm Deck	0.7 Mm Deck	0.75 Mm Deck
Magnetics, pct			
High	94.36	92.91	86.41
Low	83.44	82.72	71.28
Average	89.19	87.01	76.85
Solids, pct			
High	72.99	83.62	75.29
Low	51.74	65.88	66.66
Average	67.48	72.24	71.63
+65 Mesh, pct			
High	3.53	5.60	17.80
Low	0.93	2.13	7.33
Average	2.12	4.00	13.40
−100 Mesh, pct			
High	96.54	96.16	90.35
Low	91.39	90.41	79.07
Average	94.53	92.53	83.53

Table V. DSM Screen Oversize

	0.5 Mm Deck	0.7 Mm Deck
Magnetics, pct		
High	62.72	66.02
Low	43.97	40.51
Average	50.73	47.07
Solids, pct		
High	78.68	79.36
Low	73.09	66.08
Average	77.99	75.92
+65 Mesh, pct		
High	43.11	53.59
Low	27.88	37.38
Average	39.06	45.99
−100 Mesh, pct		
High	66.94	61.86
Low	51.08	44.28
Average	55.84	50.60

Table VI. Variations in Screening Results with 4-Ft DSM Screen, —0.5 Mm Surface

Operation, Hr	Screen Size Pct Weight			
	+48	+65	+100	−100
	Total Feed (Magnetics and Non-Magnetics)			
95	7.51	1.90	2.98	87.61
346	7.21	2.21	2.53	88.05
566	9.52	3.07	3.11	84.30
846	8.00	2.21	2.81	86.98
1103	8.17	2.42	3.62	85.79
	Oversize (Total Magnetics and Non-Magnetics)			
95	33.63	9.48	5.81	51.08
346	35.86	8.07	4.08	51.99
566	31.37	7.96	3.97	56.70
846	36.58	6.73	3.15	53.54
1103	34.71	5.43	3.44	56.39
	Undersize (Total Magnetics and Non-Magnetics)			
95	0.30	0.60	2.53	96.54
346	1.50	0.79	2.64	95.07
566	0.47	1.97	3.42	94.14
846	0.49	1.24	2.34	95.95
1103	0.48	1.55	4.16	93.10

for 1124 hr and was still doing an acceptable job by our standards. Table VI shows the effect of screen wear on the separation based on combined magnetics and nonmagnetics.

The amount of magnetics varied fairly constantly in both the 0.5 and 0.7 during screen cloth life. This is laid mainly to the change in quantity and structure of the rejects which were mixed with the magnetite media to form the screen feed. The amount of magnetics in the screen oversize showed a similar variation for the same reason. At no time during testing did the percent magnetics in the DSM screen undersize reduce to the average figure shown for the conventional screen undersize (Table IV).

Use of DSM on Cyclone Underflow: A 1-ft wide DSM unit was tested on underflow from one 10-in. cyclone. Test data could not be evaluated as fully as with the units on cyclone overflows. It was determined early in testing that this material contained too many solids (80 to 83 pct) for effective screening. When solids in the screen feed were reduced to about 70 pct, separation was effective. Magnetics in the screen oversize were reduced to 15 to 20 pct. Magnetics in these screen feeds were in the 35 to 45 pct range and 86 to 91 pct in the screen undersize.

If DSM screens were to be used on cyclone underflows, undersize would have to be sent to a thickener for water removal. Fine medium could be effectively deslimed by converting the thickener to a hydroseparator, magnetizing the hydroseparator feed, and adding dilution water.

Summary:

1) Capacity of the DSM screen is high—35 to 40 long tons per hr of pulp per ft of screen width at 70 pct feed solids.

2) In this application, wear life appeared to be upward of 1200 hr, or 13,700 long tons per sq ft.

3) The screen reduced primary magnetic float separator losses 86 pct. Quoting reduction in overall losses is not justified due to differences in plant magnetic separator efficiencies, except as stated.

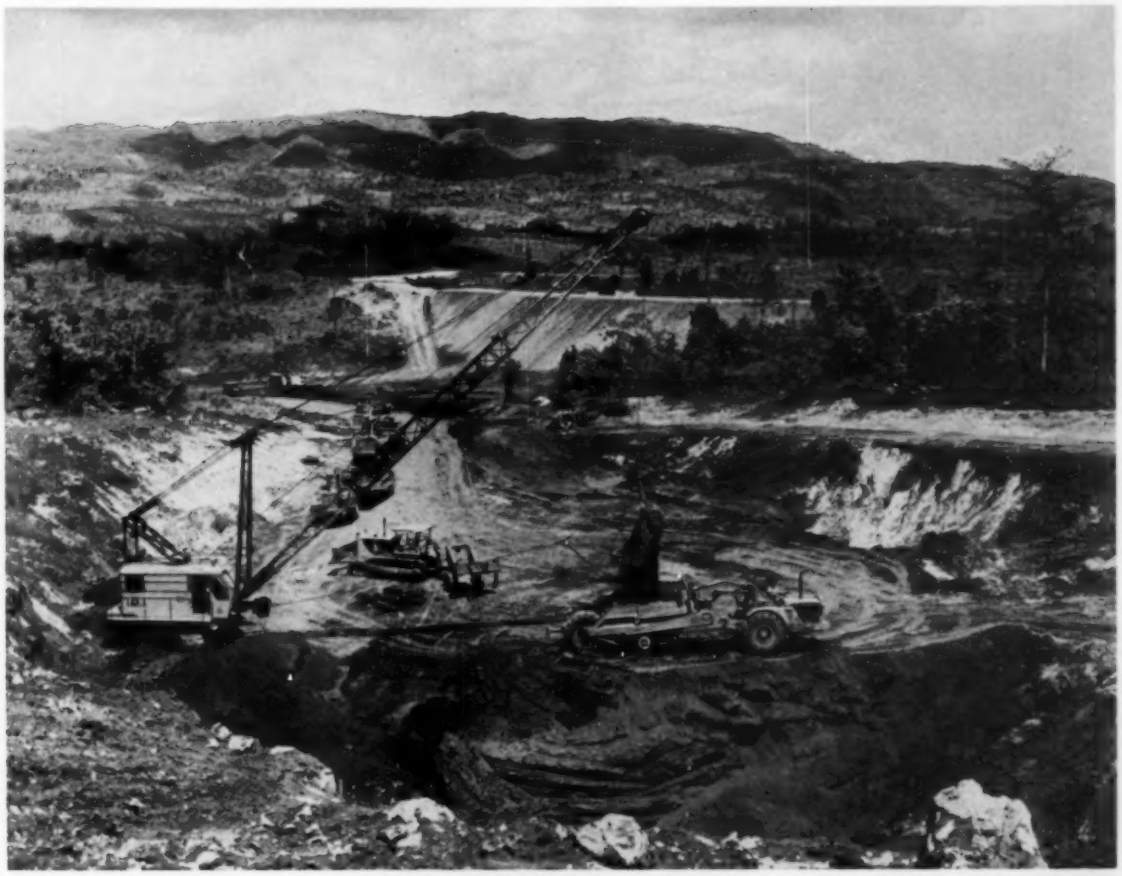
4) Reducing media to be cleaned would reduce the number of magnetic separators needed in future plants.

5) The reduced load on the washing screens would permit the use of lighter and less expensive vibrating screens. An additional savings would be realized in reduced structural steel needs.

6) Medium losses could possibly be reduced to a point where it would be economical to blend a proportion in ferrosilicon to effect separation at a higher specific gravity than that obtainable with magnetite alone.

7) Overall operation was improved and the DSM screen unit required less operator attention for uniform operation.

The authors of this paper are indebted to Dorr-Oliver Inc. for making these units available for test, to V. R. Reynolds, Dorr-Oliver Research and Development Engineer for assistance throughout the project, and to the Cleveland Cliffs Iron Co. for permission to publish the foregoing data.



This open pit bauxite operation of Alumina Jamaica Ltd. at Mandeville handles 1800 tpd of ore.

JAMAICAN BAUXITE IN THE WEST INDIES ECONOMY

Close to large markets and possessing some of the world's largest bauxite deposits, Jamaica expects stepped-up mining will bring production to 6 million tons annually by 1959.

by SMITH BRACEWELL

First evidence of bauxite in Jamaica resulted from an analysis of a soil sample collected at Bull Savannah in 1938 during a systematic local investigation of the island's soil types.

Results of subsequent work indicated the possibility of the occurrence of deposits of commercial grade and dimensions, and in 1942, with a view to emergency development of the deposits as a war measure, the Jamaican Government declared all bauxite in the colony to be Crown property.

Arrangements were made for a detailed investigation and evaluation of the deposits, and in 1943 a shipment of 2500 tons was sent to the U.S. for large scale testing. It was found that the material was low grade and refractory and development of the deposits had to be postponed. The original vesting legislation was repealed.

S. BRACEWELL is on the staff of the Overseas Geological Surveys, London, England.

Draglines, dozers, rippers, and scrapers work simultaneously at this deposit in the high plateau area of Jamaica.

At Port Esquivel a freighter takes on a cargo of alumina bound for treatment at a Canadian reduction plant.

Later, extensive prospect areas were acquired by subsidiaries of three North American aluminum companies: Jamaica Bauxite Ltd., a subsidiary of Aluminium Ltd., and subsidiaries of two American companies, Reynolds Metals and Kaiser Aluminum & Chemical Corp. By 1950 proved bauxite resources on the properties owned or controlled by these companies totaled 130 million tons, with additional possible reserves of some 200 million tons.

Under a 1947 law, bauxite and nearly all other minerals in Jamaica were again vested in the Crown, and in the same year legislation was enacted providing for the control and regulation of mining, and for the payment of royalties on the minerals extracted.

Marshall Plan Aid: Development of the deposits was aided by financial assistance to two of the companies by the U.S. Government under the Marshall Aid Plan.

The Canadian company decided to manufacture alumina in the colony and to erect a factory at Kirkvine, near deposits at Shooters Hill, and the name of the subsidiary was changed to Alumina Jamaica Ltd. Mining began in December 1952, and the first shipment of alumina was made in 1953. Most of the alumina is sent to the parent company's reduction plant at Kitimat, B. C.

The two American companies export crude, semi-dried bauxite to their U.S. plants. Reynold's first shipment was made in June 1952, and Kaiser's first during the following year. About a third of U.S. bauxite needs are now obtained from Jamaica.

Operations Expanding: During 1956 nearly 3 million long tons of bauxite valued at nearly $22 million and over 200,000 tons of alumina valued at $16,156,000 were exported from Jamaica. Production was estimated to total 3.6 million tons, equivalent to 3.1 million dry tons after 13 pct moisture allowance, and this is equivalent to 18.4 pct of total world production that year.

The scale of mining operations is being rapidly increased, and it is anticipated that by 1959 annual production may reach about 6 million tons. In addition, the annual production capacity of the Kirkvine alumina plant has been increased to nearly 500,000 tons per year, and Alumina Jamaica Ltd. is building a second plant at Ewarton which will have a capacity of 220,000 tons per year.

Reserves: The bauxite deposits occur on a dissected plateau about 1000 to 3000 ft above sea level, and appear to have been formed through tropical weathering of a limestone formation which covers about five-eighths of the total area (4411 sq miles) of the island. Ore reserves have recently been estimated at between 500 million tons and 600 million tons, or about a quarter of the world total, and are sufficiently large to last about 100 years at the expanded rate of production.

West Indian Asset: The capital expenditure of the three bauxite companies in Jamaica up to the end of 1956 has been estimated to total $99.4 million, and it is expected to reach over $160 million this year. The industries give direct employment to about 6000 people. Wages paid in Jamaica in 1956 were estimated to amount to $2.8 million and other local expenditure to $7 million.

In March 1957, the Jamaican Government and the bauxite companies agreed on an increase in the rate of royalty and on higher income taxes. Because of this and projected expansions, Government revenue from the industry is expected to rise from about $2.8 million during fiscal 1957-1958 to $19.6 million and possibly to more than $25 million in the year 1960-61, or to about a quarter or even a third of the country's total revenue.

The industry is therefore an important asset, not only to Jamaica itself, but to the West Indian Federation as a whole. Like the oil industry of Trinidad, it should serve to strengthen the Federation and to insure its economic stability and independence.

APPLICATION OF ELECTROSTATICS TO POTASH BENEFICIATION

by I. M. LeBARON and W. C. KNOPF

In the Carlsbad area potash is dry-mined and wet-concentrated. Wet concentration involves recirculation of saturated brines, with resultant difficulties of brine disposal and inherent losses in recovery through solution of the KCl.

A dry beneficiation process for potash minerals would offer many advantages over present methods. International Minerals & Chemical Corp. has been working on development of a dry process for some time. This article is a progress report.

Potash ores available in this country are largely mixtures of halite and sylvite contaminated with slimes and often with many sulfate and magnesium minerals. Electrostatic concentration of KCl when the contaminating minerals are in low percentage has been accomplished. Continuous production of better than 60 pct K_2O concentrate from high potassium sulfate ores has not been demonstrated at the present time.

Laboratory Procedure: Laboratory work on electrostatic beneficiation of potash minerals has been carried out using both pure crystals and mined ore. Electrostatic separation of the two main components of potash ore, sylvite (KCl) and halite (NaCl), is accomplished by first heat-treating the ore to allow for electric charging of the particles. Preferential exchange of electrical charges between different mineral particles through surface contact is the principal mechanism involved.

After proper conditioning of the particle surfaces, the oppositely charged minerals are dropped vertically into a horizontal electric field having a field gradient from about 5000 to 15,000 v per in. The particles are free-falling in the field. A suitable power supply is used to produce the proper total voltage for the electric field. Total required voltage is, of course, a function of electrode spacing. A typical electrode arrangement with power supply is shown in Fig. 1. In general, the total voltage on any system is 75,000 to 90,000 v. Power consumption is negligible, as leakage at insulators and corona discharge are the main losses in the system.

Optimum preheat temperatures for pure material components generally are not the same as for mined minerals. Fig. 2 shows clearly that maximum recovery on a 50 pct pure KCl, 50 pct pure NaCl mixture occurs at a preheat temperature of about 600°F. In this test the preheat mixture was allowed to cool to about 225°F before dropping through the electric field. The optimum temperature for separation is practically never the optimum temperature of preheat.

Optimum separation for mined Carlsbad potash ores occurs when a preheat temperature closer to 900°F is used, as shown by Fig. 3, which plots percent sylvite (KCl) in the concentrate and tails as a function of preheat temperatures. Here again the ore was allowed to cool to about 225°F before separation. It should be noted that efficiency of separation increases continuously with increasing preheat temperatures until incipient fusion of the ore takes place at about 950°F.

The increase in optimum preheat temperature for Carlsbad ores over the pure minerals can be traced to the effect of the clay slimes intimately associated with the mined potash. If the slimes associated with the ore are removed by washing with alcohol or other non-aqueous material, the necessity of preheating to the high temperature is removed. This temperature range has been proved critical within these limits during continuous pilot plant operation.

Concentrate and tailings grade and optimum recovery also are functions of the temperature of the potash mineral particles during separation in the electric field. Fig. 4 presents data indicating that feed to the rougher pass should range between 150°F and 275°F for best results. It has been found by subsequent pilot plant work that these temperatures can be maintained in actual operation.

Table I. Typical Mineral Composition of Products

	Weight Pct				
	Phase I Conc.	Phase I Tails	Final Conc.	Phase II Tails	Final Tails
Sylvite	80.99	3.01	93.64	38.28	5.35
Halite	12.33	91.09	2.09	47.30	88.98
Langbeinite	3.95	4.29	2.79	11.31	3.40
Other Sulfates	0.78	0.13	0.21	0.27	0.50
Insoluble	1.94	0.60	1.29	2.83	0.75
Pct K_2O as KCl	51.16	2.31	59.15	24.16	3.30
Total K_2O	52.00	3.29	59.78	26.74	4.01

Table II. Effect of Sulfate Removal on Final Concentrate

	Pilot Plant Concentrate (No Correction)				Pilot Plant Concentrate (Assuming SO_4 Removal)			
Run	Tons	K_2O, Pct	Ind. Rec.	Act. Rec.	Tons	K_2O, Pct	Ind. Rec.	Act. Rec.
A	219	58.8	84.0	72.5	209	60.7	83.7	71.5
B	185	59.5	77.4	64.7	177	61.0	77.1	63.7
C	179	58.3	86.8	80.3	168	60.8	86.6	78.0
D	193	59.3	77.9	62.8	185	60.8	77.6	61.6
E	194	59.8	91.4	68.3	101	61.1	91.4	67.6
Total	880	59.1	82.4	69.2	840	60.9	82.1	68.1

I. M. LeBARON, Member AIME, is Vice President of the Research Division and W. C. KNOPF Assistant Director of Research, International Minerals & Chemical Corp. Central Research Laboratory, Skokie, Ill. TP 4761H. Manuscript, Dec. 2, 1957. New Orleans Meeting, February 1957.

The Transactions papers appearing in MINING ENGINEERING *during 1958 will subsequently appear in AIME Transactions Volume 211, and may be permanently referenced to that volume.*

Pilot plant process and process equipment fall into two major sections, preparation and concentration.

Preparation Section: Run-of-mine ore is first crushed to −14 mesh for liberation. This is accomplished by a primary crusher reducing the ore to −1 in. and by a secondary crusher operating in closed circuit with vibrating screens. It is desirable to produce a minimum of fines in the crusher circuit to improve recovery and efficiency of concentration. This will be discussed later.

Crushed ore is fed to a 10x90-ft rotary kiln and heated to 800° to 900°F. This deactivates the slimes that coat the particles and allows a differential electric charge to form on particle surfaces on cooling. The kiln is gas-fired and operation is countercurrent. The hot ore then is fed to a cascade-type cooler and cooled by a countercurrent flow of air to about 250°F. The heated cooler discharge air is utilized as secondary air in the kiln. Ore is now ready for separation into its components in an electric field.

Concentration: Conveyor belts and elevators send the cooled ore at 225°F to the rougher pass in the concentration building, see Fig. 5. This is the phase I section of the concentration operation, consisting of a rougher and a scavenger pass. Each of these units contains three pairs of electrodes arranged as indicated. The products to be recycled from each unit are caught in hoppers, conveyed to an elevator and re-combined with the feed to that unit.

Tailings from the upper half of phase I rougher and from the phase I scavenger are sent to waste. However, a portion of the tailings approaches 99 pct NaCl in purity and can be utilized as industrial salt without further processing. A d-c potential of about 90,000 v is required to operate the concentrating sections, but very little power is required to maintain a suitable electric field between the electrodes. These 500 to 600 watts are needed primarily because of corona losses.

Many variables pertaining to this rougher operation have been studied in the pilot plant. Sulfate minerals associated with the sylvinite ore—such as langbeinite, leonite, kainite, and polyhalite—affect the efficiency of beneficiation; so does the amount of slimes adhering to the surfaces of particles to be separated. The duration and degree of agitation during processing; cooling methods and times of cooling; retention time of the ore in the kiln; recycle loads; excessive fines and many other operating conditions have also been studied.

The rougher scavenger flowsheet (indicated in Fig. 5) operating on ores of 10 to 19 pct K_2O produced a rougher concentrate consistently analyzing 48 to 54 pct K_2O. Operation to this point is simple and straightforward. Ores that are high in slimes and difficult to treat may be concentrated to 48 to 54 pct K_2O inexpensively and with resultant deactivation of slimes. For ores that are difficult to concentrate, it may well be economic to operate through this rougher stage at 50 pct K_2O concentrate, following it with wet concentration to obtain final 60 pct K_2O saleable grade. Concentration to this point has been quite successful.

On clean ores low in sulfate running above 20 pct K_2O the rougher concentrate will run about 55 pct K_2O and can be run through a cleaner and recleaner stage in closed circuit to produce a final 60 pct K_2O concentrate. This has been demonstrated on a

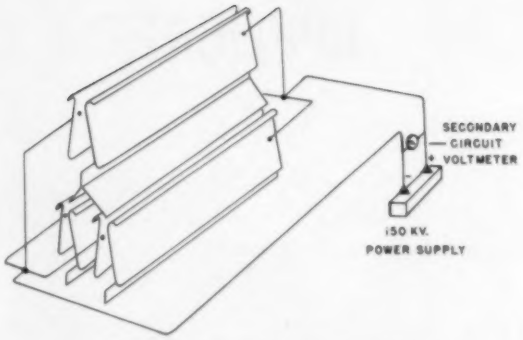


Fig. 1—Typical electrode arrangement.

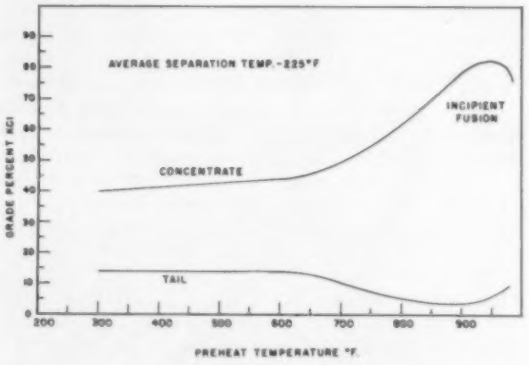


Fig. 3—Preheat temperature vs percent KCl, potash ore.

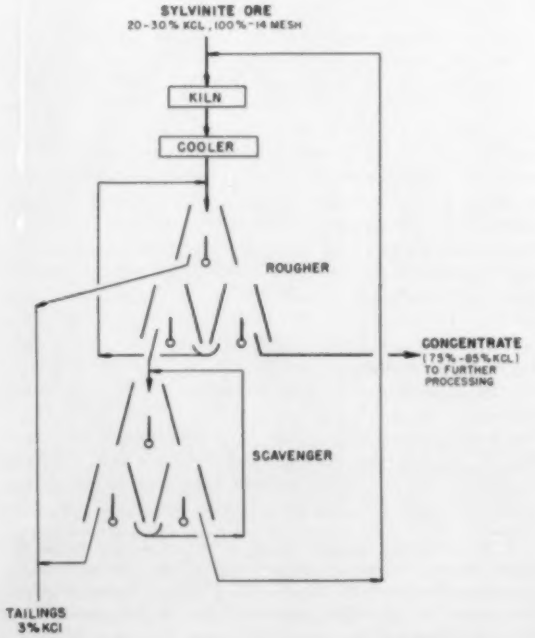


Fig. 5—One-stage electrostatic concentration, potash ore.

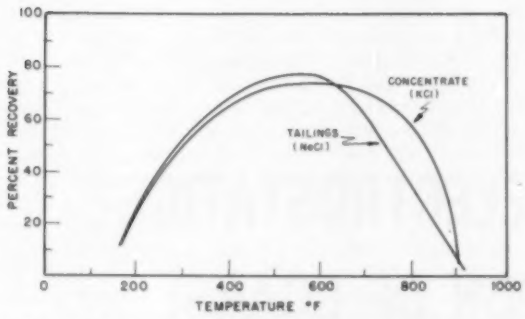


Fig. 2—Preheat temperature vs percent recovery.

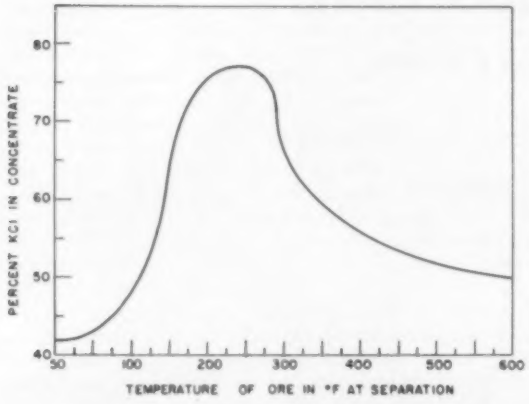


Fig. 4—Rougher feed separation vs temperature.

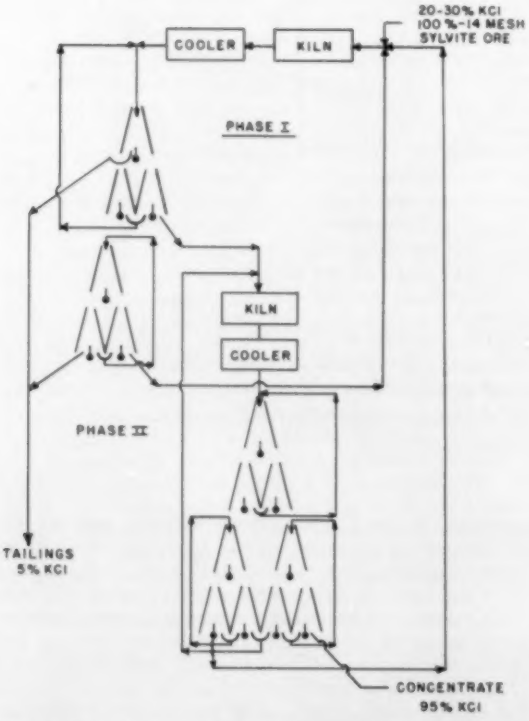


Fig. 6—Two-stage electrostatic concentration, potash ore.

sub-pilot plant scale with rates running about 1 tph. However, on ores high in sulfate such cleaner and recleaner operations result in very little increase in K_2O concentration.

For further dry concentration the rougher concentrate is reheated before cleaning and recleaning. A typical flowsheet is shown in Fig. 6. To determine its operating characteristics, the dry concentration pilot plant at Carlsbad has recently operated continuously on sylvite ore using this flowsheet. Concentrate grades produced during this period have varied from a low of 56.3 pct K_2O to a high of 60.2 pct K_2O, with an average for the period of 59.1 pct K_2O. Saleable grade concentrate analyzed 60 pct K_2O. The biggest single reason for not turning out a 60 pct K_2O product consistently is that the sulfate minerals tend to report to the concentrate. Table I gives a typical mineral composition of various products in the flowsheet shown in Fig. 6.

Table II shows the effect of sulfate on the grade of concentrate for various runs. Langbeinite was the chief sulfate mineral found during these runs. Removal of the sulfates allows the concentrate grade to approach 61 pct K_2O. Table II also lists the indicated and actual recoveries for various tonnage runs using the Fig. 6 flowsheet. High concentrate grades with indicated recoveries above 90 pct were unusual. K_2O had to be bled to the tails to remove enough sulfate to produce high grade. This affects the recovery of the operation materially.

The difference between actual and indicated recovery is largely a loss of fines. In the kiln operation fines swept to the dust collector were not returned to the circuit. At least 10 pct of the feed was lost in this way.

Fines of less than 150 mesh cannot be efficiently concentrated at the same time the coarser material passes through the electrode system. About half the loss in fines was in this screen mesh fraction. Through efficient dust collection and air separation the other 50 pct of the loss could have been returned to the circuit.

These data indicate the importance in this type of processing of reducing the percentage of fines produced in feed preparation.

FUTURE PROGRAM

To develop the present dry operation into a complete unit for concentration of potash ores under 20 pct K_2O and high in sulfate, at good recovery producing better than 60 pct K_2O concentrates, the following difficulties must be overcome:

1) Losses in the fines must be decreased. This can be done by handling fines in a separate circuit and by better air sizing.

2) Sulfate removal and concentration must be improved in the circuit. There are indications that with the proper flowsheet sulfate can be produced as a separate concentrate. This is being studied.

It is estimated that the cost of concentrating 5000 tpd of ore to a 50 pct K_2O product by using the Fig. 5 flowsheet will be 60¢ to 80¢ per ton of ore fed. This includes amortization of capital but is only plant level expense. The cost for concentration using the flowsheet in Fig. 6 is estimated at 75¢ to $1.25 per ton of ore fed.

Work is continuing at International's Research Division to perfect this process for use on potash ores.

Discussion of this article sent (2 copies) to AIME before Nov. 30, 1958, will be published in MINING ENGINEERING.

APPLICATION OF ELECTROSTATICS TO CONCENTRATION OF COARSE PEBBLE PHOSPHATE

by E. NORTHCOTT and F. N. OBERG

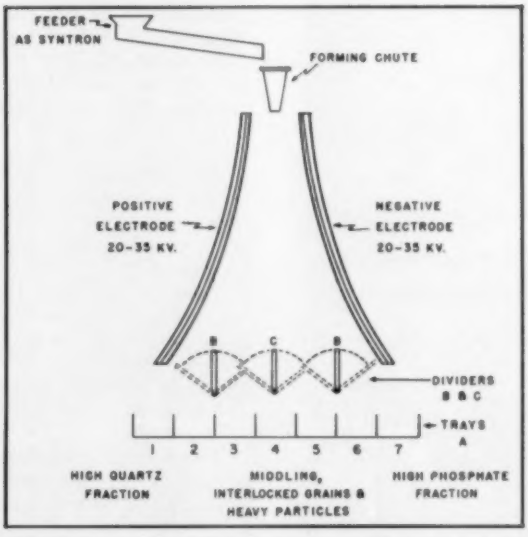


Fig. 1—Single LeBaron-Lawver electrode set showing feeder and the product dividers for batch A and for the pilot plant (B and C) operation.

By electrostatic separation, coarse Florida pebble phosphate, too low-grade to find a ready market, can be upgraded to a satisfactory saleable product. Pebble running from 60 pct bone phosphate of lime may be upgraded to 73 to 77 pct BPL depending on the mineralogical structure of the pebble and the nature of the silica impurity.

High-grade concentrates from Florida pebble phosphate deposits have long been recovered by wet methods. When work was begun in the field, only the coarse pebble (generally +1 mm) was recovered. In the 1920's a froth flotation process was developed to separate quartz from the finer phosphate fractions, but this method proved unsatisfactory for treating the intermediate fraction (−1 mm +35 mesh). Consequently various other processes were adapted, including agglomerate tabling and spiral separation of reagentized feed. Today the three processes are used—washing and screening for coarse pebble, tabling or spiraling for intermediate sizes, and flotation for −35 mesh material.

E. NORTHCOTT, Member AIME, is Manager of the Florida Experiment Station, Research Div., International Minerals & Chemical Corp., Mulberry, Fla. F. N. OBERG, Member AIME, formerly with the Research Div., is now with Homestake Mining Co., New Mexico Partners, Grants, N. M. TP 4762H. Manuscript, Dec. 2, 1957. New Orleans Meeting, February 1957.

These wet concentration methods yield high-grade products from the finer fractions of the ore, but the coarse pebble is not beneficiated further than removal of the fine particles. The grade of the coarse product is its natural grade, and when this is low the product has a limited market. The trend of grade in the Florida deposits is downward. High-grade ore has been selectively mined and depleted, but extensive areas of lower grade ore remain. To obtain a desirable product from this ore, beneficiation will be required.

The wet processes used to concentrate fine material follow naturally the mining and wet ore transporting methods used in the Florida fields. For this reason, and because wet process plants are well established in the area, the dry electrostatic separation process has not been extensively applied even though it has proved practicable. To treat the finer size materials by dry methods would involve drying large tonnages of silica. However, +1 mm pebble, which is higher grade and contains less silica, can be dry concentrated for less cost per unit of phosphate. It is dried according to standard practice. To treat it electrostatically would not involve changing present plants or installing more drying capacity. The advantages of dry-crushing and prevention of slime loss make the dry concentration of the coarse pebble attractive. A valuable concentrate can be made from inexpensive pebble by simple crushing to liberate silica at about 14 mesh, moderate heating, and electrostatic treatment.

International Minerals & Chemical Corp. operated an electrostatic pilot plant in which raw ores and spiral and flotation feed were concentrated. The plant used the LeBaron-Lawver free-fall process, which requires no contact between electrodes and ore particles. The principle involved in this process is based on the fact that particles of different minerals are charged differently by various phenomena and will react differently when subject to an induced high-voltage electric field. In practical application the charge is developed, during and after heating, by particle-to-particle contact, or by contact with a metal surface. Temperatures to which ores are heated and cooled before separation vary with the specific minerals to be separated. The optimum preheat temperature for pebble phosphate is 300° to 350°F, followed by cooling to 200° to 250°F before the ore is dropped through a free-fall of 6 to 9 ft between oppositely charged electrodes.

These electrodes (Fig. 1) are connected to a potential differential of 40 to 70 kv. In phosphate beneficiation the quartz and phosphate, bearing negative and positive charges respectively, are deflected in opposite directions by the external electric field. Ore particles not freed by crushing, too heavy to be sufficiently deflected by the electrodes, or prevented from deflection by other particles, fall into a central position as a middling fraction. For testing purposes in a batch process, the ore is ordinarily split into a number of portions as represented by the seven fractions shown at *A* in Fig. 1. Table I shows typical results obtained by a batch concentration test on a low-grade +1 mm Florida pebble sample. It will be noted that the percentage of BPL* (bone phosphate of lime, or tricalcium phosphate) in the fractions increases as the negative electrode is approached, and conversely the silica or quartz content decreases. The center portion is near feed grade.

* 1 pct of BPL is equivalent to 0.45762 pct P_2O_5.

By selecting and combining the individual portions, it is possible to make products that can be called concentrates, tailings, and middlings. For example, if portions 5, 6, and 7 (Table I) are combined, a concentrate assaying 75.6 pct BPL and 2.8 pct SiO_2 will be obtained. Likewise portions 1, 2, and 3 will produce a fraction containing 30.2 pct BPL and 55.1 pct SiO_2. Portion 4 will then be left for recycle or for further treatment.

Using this established test procedure, a large number of batch tests have been performed on samples of coarse phosphate pebble products. It was found that a high-grade concentrate could be produced, generally with high phosphate recovery. Table II shows the amount of 75 pct BPL concentrate produced in a number of tests. With pebble feeds ranging from 67.2 to 70.1 pct BPL, 62 to 92 pct of the phosphate was recovered as a 75 pct BPL concentrate, and the silica content was dropped from over 10 pct to less than 6 pct. These results were obtained by a single pass of LeBaron-Lawver concentration. It is stressed that in this tabulation no credit is taken for further recovery by middling recycle. Such recycle is unusual in plant practice.

In plant practice, where a middling is made and recycled, the division into the three products is not done by splitting into seven fractions and then recombining but is performed automatically by adjustable splitters installed between the electrodes (Fig. 1, at *B* if three products are to be made or at *C* if only two products are desired with no middling).

It can be demonstrated by calculation from Table I that the electrostatic fractions forming the low BPL product (portions 1, 2, and 3) cannot be called true tailings by acceptable metallurgical standards. Although this product contains only 11.7 pct of the phosphate values, its grade is not as low as throw-away tailings made by wet concentration processes.

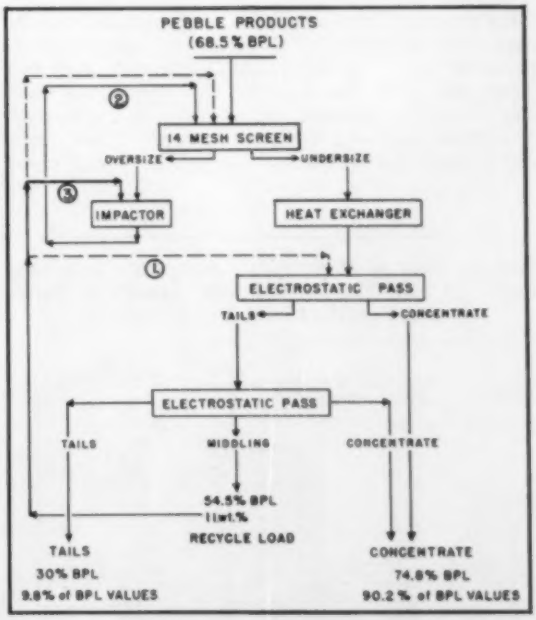


Fig. 2—A flowsheet and bone-phosphate-of-lime balance of two-stage electrostatic sub-pilot plant.

Table I. Electrostatic Concentration of Crushed Coarse Pebble-Quartz-Phosphate Rock System

Electrode	Feed: +1 mm crushed through 14 mesh Portion	Wt, Pct	BPL, Pct	SiO_2, Pct
Positive	1	4.3	19.5	72.3
	2	7.8	27.4	59.2
	3	12.3	35.7	46.5
	4	16.9	65.2	20.3
	5	23.0	74.8	3.8
	6	25.8	75.9	2.3
Negative	7	9.9	77.0	1.5
	Feed	100.0	62.8	18.5

However, if the low-grade product is treated by another step of electrostatic beneficiation, the quality of the high-silica fraction will compare favorably with that of tailings produced by flotation or spiral beneficiation. This additional step of separation is analogous to scavenger flotation.

This step was incorporated in a double pass sub-pilot plant (capacity, 600 lb per hr) designed and constructed to treat +1 mm pebble products. It is represented by the flowsheet, Fig. 2, which also shows a typical BPL balance.

In this plant the coarse pebble is fed to an 18-in. Sweco separator with a 14-mesh screen deck, in closed circuit with an impactor. Undersize from the screen enters a vertically-baffled muffle-type heat exchanger, where the temperature of the ore is raised to 300° to 400°F. The heated feed is then elevated to the top of a 30-ft enclosed tower containing two sets of LeBaron-Lawver electrodes. The upper electrode is fed at a constant rate by a Syntron feeder. The ore is spread evenly to fall in a ribbon parallel to the electrodes. In this particular plant the forming chute directly above and between the electrodes is 4 in. wide, and the electrodes are 12 in. wide. They are mounted 10 in. apart at the top and spread to 36 in. at the bottom. The height of the electrodes is approximately 9 ft. A conventional product divider (Fig. 1, *C*) splits a concentrate from the stream. This stream is removed from the tower by a suitable chute. The tailings from the upper pass form the feed for the lower and final pass. They are collected in a hopper and reformed by a chute directing them between the lower electrodes. Material at the bottom of the lower electrodes is divided by adjustable splitters (at *B*, Fig. 1) into concentrates, tailings, and middlings. The lower concentrates and tailings are removed as finished products, while the middlings are recycled to process. During sub-pilot plant runs, various points of middling return were tested, as shown at 1, 2, and 3 of Fig. 2. It was found that recycle to the impactor produced the most satisfactory results.

Table II. Yield of 75 Pct BPL Concentrate from Low Grade +1 MM Phosphate Pebble. Results of Batch Testing with No Middling Recycle

Test	BPL, Pct Head	BPL, Pct Concentrate	BPL, Recovery, Pct	SiO_2, Pct Head	SiO_2, Pct Concentrate
1	69.0	75.0	80	13.3	4.7
2	70.0	75.0	80	11.2	4.2
3	67.8	75.0	82	12.6	3.9
4	69.7	75.0	76	11.1	5.4
5	70.0	75.0	70	11.2	4.2
6	68.4	75.0	89	12.0	4.0
7	69.3	75.0	62	11.4	4.5
8	68.0	75.0	80	12.1	3.9
9	70.1	75.0	73	10.1	4.2
10	67.2	75.0	70	13.4	4.0
11	70.0	75.0	92	11.5	4.7
12	67.4	75.0	85	12.1	3.7
13	67.7	75.0	85	12.1	3.5
14	68.0	75.0	86	11.9	4.8
15	69.7	75.0	90	10.9	4.3
Average	68.8	75.0	80	11.8	4.3

Other variables that might affect the separation have been investigated during the batch and sub-pilot plant test runs. Among these are: 1) degree of crushing; 2) preheat temperatures of the ore at separation and of the surrounding atmosphere; and 3) electrode voltage. Test results have proved that the ranges given in this article produce satisfactory separation.

Most of the tests, both batch and sub-pilot plant, were performed on *pebble fines*. This product is removed from dried coarse pebble to improve the size quality and provide a more uniform feed to electric furnace plants. Some of the fine material results from inefficient removal of small particles in washing plants and from breakdown of soft and agglomerated particles during drying. It represents 50 to 60 pct of the entire pebble when screened at 8 or 10 mesh. Its grade is inferior to other fine phosphate materials, averaging about 68.5 pct BPL compared to over 75 pct BPL for flotation and spiral concentrates. With large amounts of wet concentrates available, the off-grade product does not find a ready sale. Concentration is required to make a desirable product.

Enough testing was also done on the oversize pebble to show its amenability to electrostatic concentration. Beneficiation of this product should be seriously considered because of the depletion of high-grade ore reserves and a steady decline in grade of pebble being mined. Large areas of low grade ore are available in the Florida deposits, but this pebble cannot command a premium price in the electric furnace burden market. Electrostatic beneficiation of pebble products is more advantageous than wet methods for a number of reasons. It can be dried in facilities already installed and operating. It can be dry-crushed for electrostatic separation without the slime loss that would accompany wet grinding for flotation or spiral concentration.

Preliminary cost estimates are of doubtful value when based on such small-scale units as a 600-lb per hr sub-pilot plant, but it is indicated that an electrostatic plant to treat 500,000 tons of low grade pebble per year will cost about $600,000. This amount would provide for the crushing, screening, heating, and separating equipment, with such necessary auxiliaries as conveyors, elevators, dust collectors, and surge bins. It has been assumed that drying and storage facilities will not need enlarging but that those currently in use will be adequate for use with the electrostatic plant.

On the basis of amortization of this capital as well as current labor and material costs, it is further estimated that plant will produce 380,000 tons of concentrates for about $0.50 per ton, plant level cost not including raw material charges. This figure allows no credit for tailings or for dust, which will undoubtedly have some value. As stated, these figures are based on small-scale tests, and pilot plant operation on a larger scale is now indicated.

Discussion of this article sent (2 copies) to AIME before Nov. 30, 1958, will be published in MINING ENGINEERING.

APPLICATION OF ELECTROSTATICS TO FELDSPAR BENEFICIATION

by E. NORTHCOTT AND I. M. LeBARON

Before describing the electrostatic processing of feldspar, it might be well to review some of the basic definitions and terminology of feldspars. The feldspar minerals constitute a group of aluminosilicates of potassium, sodium, and calcium. Barium feldspar sometimes occurs naturally but is very rare. Hardness varies between 6 and 6.5 and specific gravity between 2.5 and 2.8. Color is generally white or pale shades of red, yellow, or green. The approximate chemical composition of the principal feldspars is given in Table I.

The albite (sodium aluminum silicate) and an-

E. NORTHCOTT, Member AIME, is Manager of the Florida Experiment Station, Research Div., and I. M. LeBARON, Member AIME, is Vice President, Research Div., International Minerals & Chemical Corp. TP 4763H. Manuscript, Dec. 2, 1957, New Orleans Meeting, February 1957.

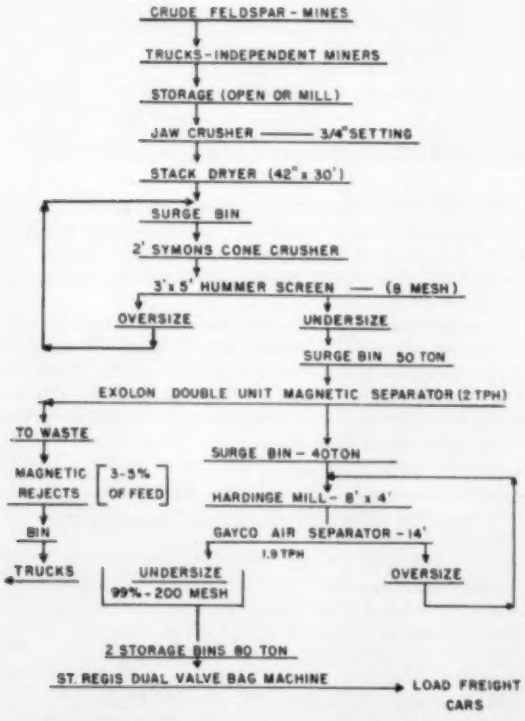


Fig. 1—Flowsheet of International's operation at Topsham, Me., prior to installation of electrostatic unit.

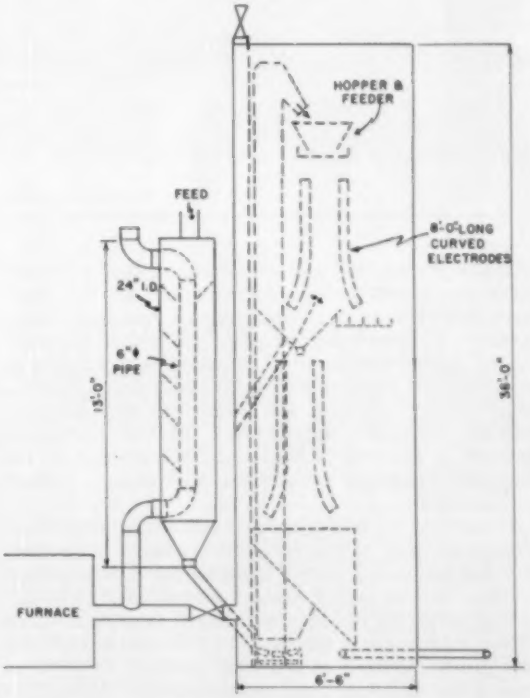


Fig. 2—Pilot plant flowsheet at Florida Experiment Station, where tests were performed on 1000-lb lots.

Table I. Approximate Chemical Composition of Principal Feldspars

Feldspar	Formula	Composition, Pct				
		K_2O	Na_2O	CaO	Al_2O_3	SiO_2
Orthoclase	$KAlSi_3O_8$	16.9	—	—	18.4	64.7
Microcline	$KAlSi_3O_8$	16.9	—	—	18.4	64.7
Albite	$NaAlSi_3O_8$	—	11.8	—	19.4	68.8
Anorthite	$CaAl_2Si_2O_8$	—	—	20.1	36.6	43.3

orthite (calcium aluminum silicate) feldspars are the end members of a series called plagioclase. These two molecules form a complete solid solution series ranging from pure soda feldspar at one end to the pure lime feldspar at the other end. Intermediate solid solutions are known as oligoclase, andesine, labradorite, and bytoconite. The general structure throughout this series is the same. Sodium and calcium may replace each other and silicon and aluminum may replace each other in the structure.

Orthoclase and albite are completely miscible at high temperatures but are miscible only to a limited extent at low temperatures. For this reason potash feldspar usually contains a little soda and, conversely, soda feldspars usually contain a little potash in the lattice. Alkali feldspar (K and Na feldspar mixtures) of medium composition separates into two phases upon cooling; one is rich in potash feldspar, the other in soda feldspar. The two form an intergrowth of oriented lamellae known as perthite. Typical analyses of a few commercial feldspars are shown in Table II.

Table II. Typical Analyses of Some Commercial Feldspars

No.	Ignition Loss	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	NaO_2
1	0.20	73.9	14.6	0.10	0.3	Tr	7.9	3.0
2	0.20	69.6	17.4	0.08	1.4	Tr	6.5	5.1
3	0.30	66.5	18.4	0.08	0.10	Tr	12.0	2.7
4	0.10	71.6	16.3	0.07	0.40	Tr	7.8	3.7
5	0.30	68.8	17.1	0.09	0.20	Tr	10.4	3.0
6	0.30	68.1	17.5	0.09	0.20	Tr	10.9	2.8
7	0.30	68.5	17.5	0.07	0.20	Tr	10.5	3.1

Many pegmatites contain feldspar, but in impure form or uneconomical concentration. In the early days rich streaks were hand-mined and then hand-cobbed, with a waste of some 80 pct of the rock mined. Effort was made to maintain purity and uniformity, but there were complaints about fluctuations in alkali content and impurities such as tourmaline, mica, and iron oxides. (Alkali content is defined as the sum of K_2O and Na_2O present in the feldspar; the alkali ratio is the ratio of K_2O to Na_2O in the ore.)

In recent years the pottery industry has utilized more and more of the flotation grades of soda spar, but there is still a strong demand for a high-potash feldspar where purity can be controlled. The object of the investigation on electrostatic beneficiation of Maine feldspar was threefold: 1) A reduction in the free quartz content of the final product, 2) perhaps even more important, an increase in the alkali ratio so that the ore could qualify completely as a high-potash feldspar, and 3) more uniformity of product without expensive selective mining.

The ore discussed in this article came from the Consolidated Feldspar operations of International Minerals & Chemical Corp. at Topsham, Me. It is a coarse-grained microcline-perthite pegmatite averaging 74 pct feldspar and 23 pct quartz. About 2 pct muscovite and trace amounts of biotite, tourmaline, garnet, and iron oxide are present. The mineral composition is as shown in Table III.

FORMER PLANT FLOWSHEET

Fig. 1 presents a flowsheet of the Maine operations before installation of the electrostatic unit. This has been retained, with insertion of the electrostatic step, which is sandwiched between the magnetic purification and the final (Hardinge) grind. Crude feldspar is delivered to the plant by truck and dumped into storage, either in the mill building or in the area surrounding the plant. From storage it is fed manually into a 10x18-in. jaw crusher set to reduce to ¾ in. The ore is then fed by bucket elevator to a stack dryer powered by fuel oil. After drying, it is again elevated and stored in a 50-ton surge bin, from which it is fed to a 2-ft Symons cone crusher, and reduced to −8 mesh. The cone crusher is in closed circuit with a 4x5-ft Hummer screen. The oversize is recycled to the cone crusher, while the undersize (−8 mesh) is delivered to another 50-ton surge bin. (During operation of the eletrostatic plant the cone crusher is set to 14 mesh.) From the surge bin the ore is fed to a double Exolon magnetic separator at about 2 tph. Magnetic rejects from this separator average 3 to 5 pct of the feed and are conveyed to a bin for ultimate disposal by truck. After leaving the magnetic separator, the nonmagnetic portion is again binned prior to being fed into a 8x4-ft Hardinge mill utilizing flint pebbles. Discharge from the Hardinge mill is separated by a 14-ft Gayco air separator into ±200 mesh products. The +200 mesh recycles to the mill and the −200 mesh is stored in 80-ton bins. From these final product storage bins the 99 pct −200 mesh feldspar is bagged in a St. Regis dual-valve machine or loaded in boxcars as the customer demands.

APPLICATION OF LeBARON-LAWVER PROCESS

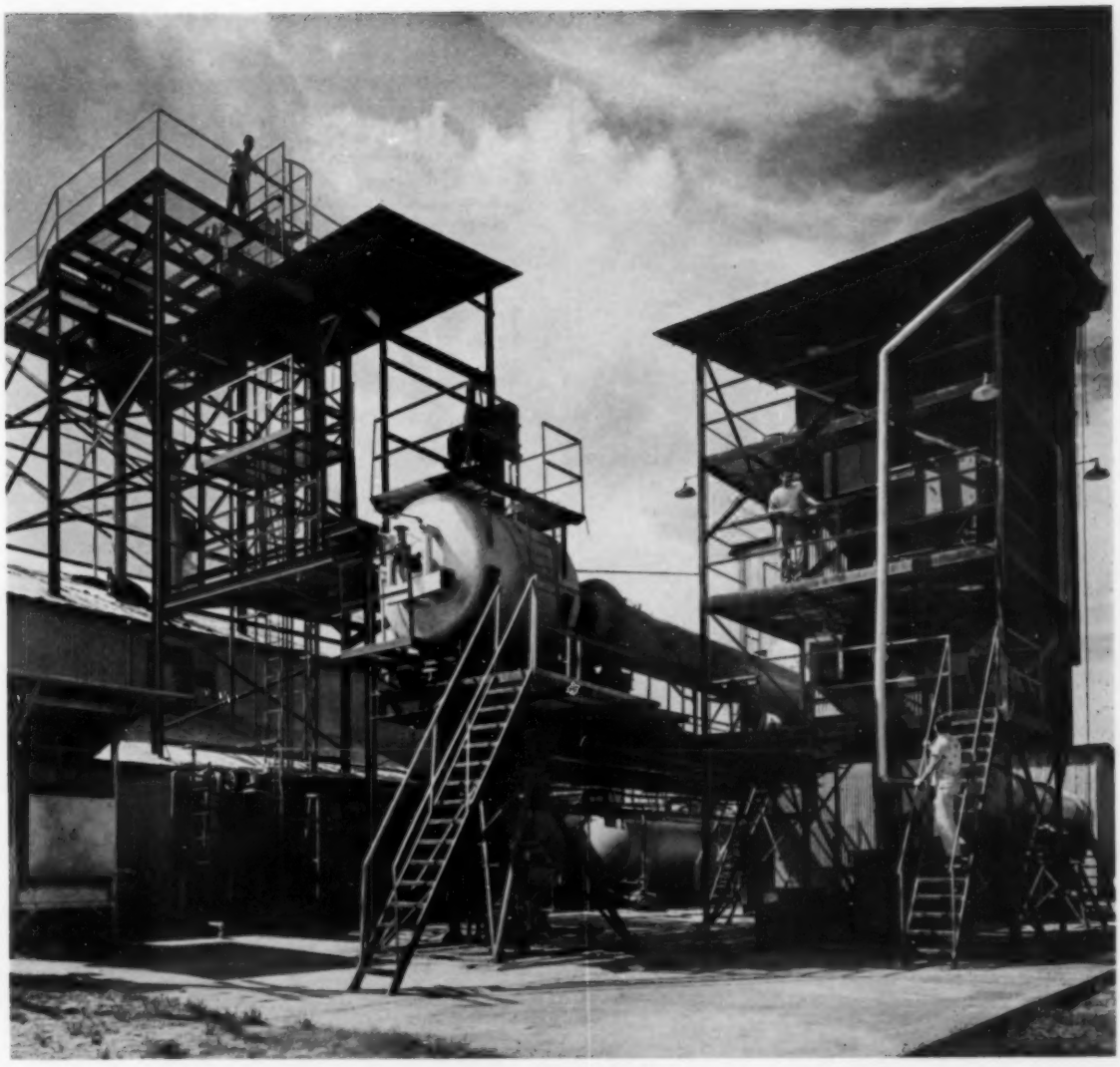
Although beneficiation of Maine feldspar by the LeBaron-Lawver process had already been investigated for several years, it is in the last five or six years that considerable technological improvement has been made.

A pilot plant flowsheet, shown in Fig. 2, was set up at the IMC Florida Experiment Station in Mulberry, and sub-pilot plant tests were made on 1000-lb lots. Prior to the pilot plant work numerous batch tests were made with results approximating those given in Table V.

Table III. Mineral Composition, Topsham Ore

From Optical Data, Pct		From Chemical Analysis, Pct	
Microline-perthite	71	Orthoclase	46
Free albite	3 to 4	Albite	24
Quartz	23	Anorthite	2
Muscovite	2	Quartz	24
Others*	trace to ½	Others*	4
	100		100

* Includes biotite, tourmaline, garnet, and iron oxides.



IMC's pilot plant at Mulberry, Fla.

Batch Testing Method: The material is ordinarily heated in an oven and manually placed into a Syntron feeder from which the ore is fed between the electrodes and collected in eight pans at the bottom of the electrodes. These pans are of equal width and the method of reporting is usually by pan number, running from left to right, or from positive to negative electrode (see Fig. 3) followed by suitable analyses. Data obtained from both the batch testing and the sub-pilot plant work indicate that given a feed of approximately 8 pct K_2O and 74 pct SiO_2 a product can be produced consistently with a K_2O content of 10.4 to 10.6 pct and a SiO_2 content of 69 to 69.5 pct. These values are at a weight recovery of 72 to 75 pct and a feldspar recovery of 93 to 95 pct. On the basis of these results, a pilot plant was installed at the Topsham plant. After demonstration runs, the pilot plant was taken over by the operating plant personnel and became an integral part of their operation.

ELECTROSTATIC PILOT PLANT

A flowsheet of the electrostatic plant is shown in Figs. 4 and 5. The equipment utilized in this pilot plant operation in order of material flow is as follows:

A.	Screw conveyor	2 hp	9-in. diam, 8½ ft long,
B.	No. 1 elevator	¾ hp	26 ft high, 4 tph
C.	Feed bin		maximum capacity (estimated)
D.	Table feeder	1 hp	26 ft high, 8 tph max-
E.	No. 2 elevator	3 hp	imum capacity
F.	Heat exchanger		
G.	No. 3 elevator	3 hp	38½ ft high, 15 tph maximum capacity
H.	Syntron feed spreader	2 kw-hr	Above 15 tph
I.	High voltage system	2 kw-hr	100 kv at 6 ma
J.	Concentration tower unit		
K and L.	Two vibratory conveyors	2 hp (total)	
M.	Hot gas supply (fire-box and oil burner 3¼ hp)		

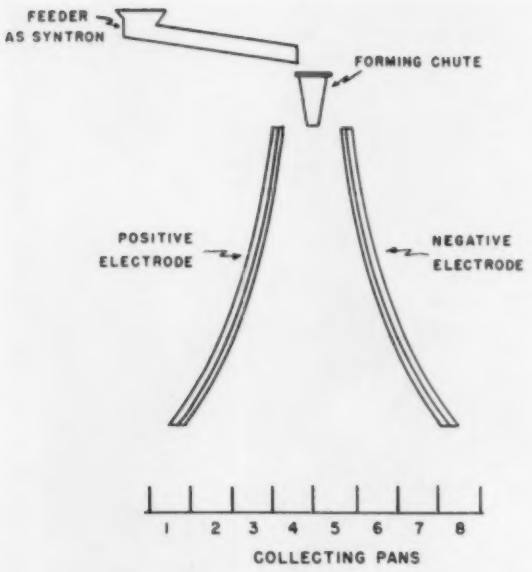


Fig. 3—A batch-type laboratory unit.

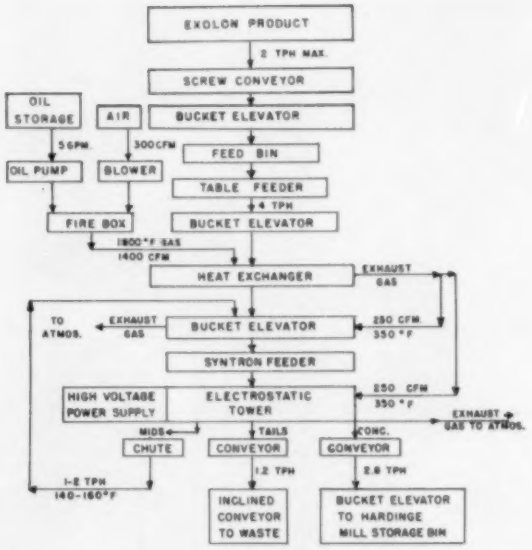


Fig. 4—Complete plant section for electrostatic process. Feed bin is surge point ahead of one-shift section.

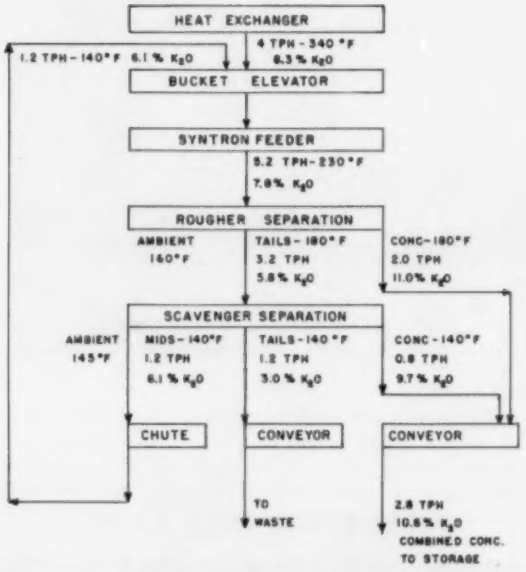


Fig. 5 (above)—Concentration section, electrostatic process. This section runs one-shift a day.

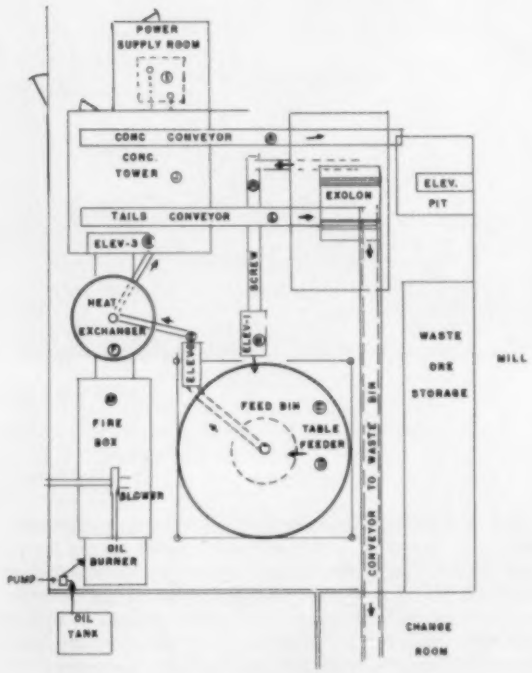


Fig. 6 (right)—Arrangement of equipment in pilot plant.

Figs. 6, 7, and 8 indicate the equipment arrangement and location of the pilot plant in relation to the Topsham mill.

Feed to the pilot plant is the −14 mesh nonmagnetic product of the Exolon magnetic separator. With reference to Fig. 6, the feed is chuted to the screw conveyor (A) and thence to the No. 1 elevator (B) and is stored in the feed bin (C). During pilot plant operation, rate of feed from the bin is controlled by a variable depth cutter blade on the constant speed table feeder (D). This material is chuted to the No. 2 elevator (E) and then fed to the heat exchanger (F). The heat exchanger discharges by gravity to No. 3 elevator (G) and the hot feed is elevated to the top of the concentration tower (J), where the ore is separated into concentrates, tailings, and middlings. The middlings are recycled to the No. 3 elevator (G) while the other products are collected on the two vibratory conveyors (K and L). Hot gases are supplied from the oil

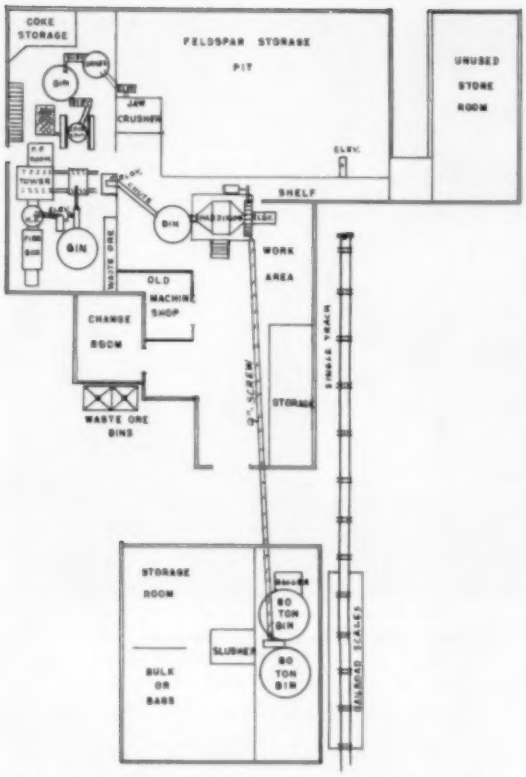


Fig. 7—Equipment arrangement, Topsham feldspar mill.

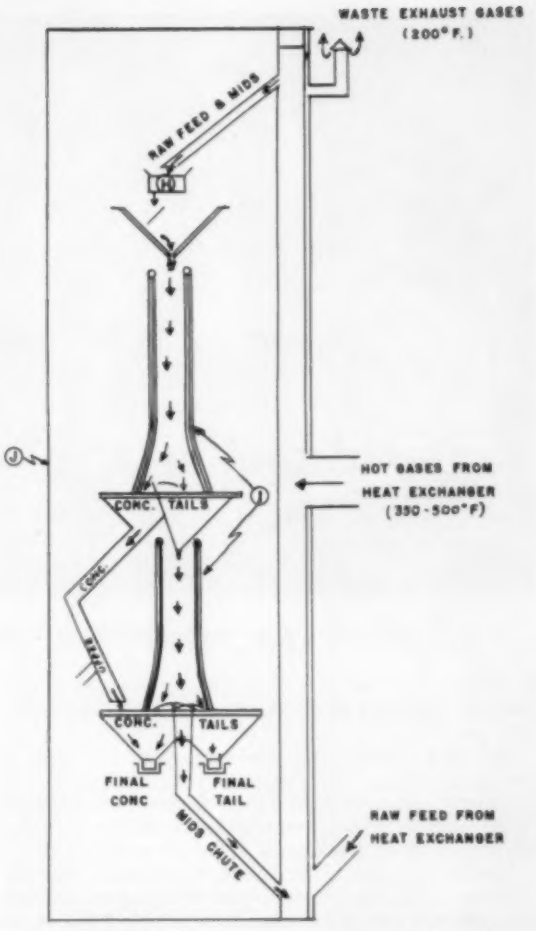


Fig. 8—Equipment arrangement, concentration tower.

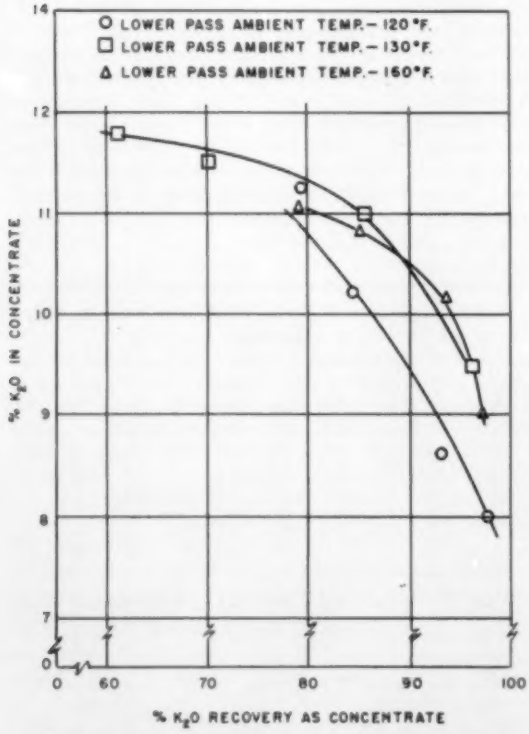

LOWER PASS AMBIENT TEMP.—120°F.
LOWER PASS AMBIENT TEMP.—130°F.
LOWER PASS AMBIENT TEMP.—160°F.
% K2O IN CONCENTRATE
% K2O RECOVERY AS CONCENTRATE

Fig. 9—Upper pass temperature in tower is 135°F.

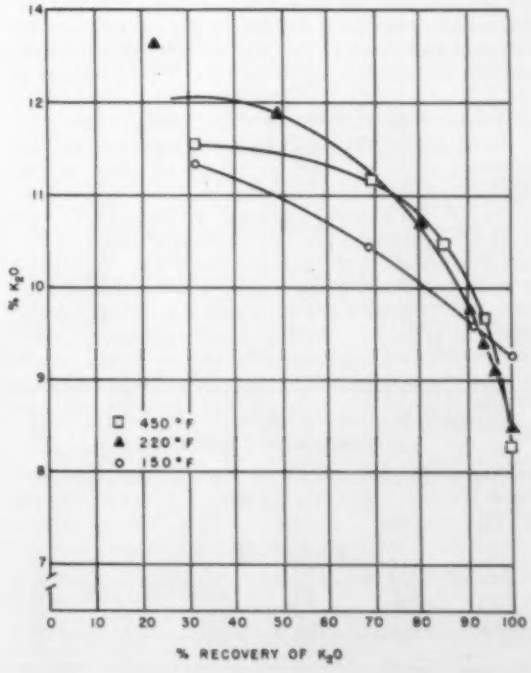


Fig. 10 (right)—The static separation of Topsham ore when it was heated to listed temperature.

A section of the International Minerals & Chemical Corp. Florida Experiment Station.

burning firebox (M) to the bottom of the heat exchanger (F).

Ore flow within the concentrating unit (J) is shown in Fig. 5. The heated ore is fed to a 5-ft Syntron spreader. From the Syntron a forming chute deflects the curtain of ore midway between the upper pass electrodes. A concentrate is withdrawn by means of an adjustable splitter and the residue is collected in another forming chute and fed to the lower electrodes. Here in the lower pass another concentrate is produced which joins the upper concentrate to form the high potash feldspar product. In the lower pass a second adjustable splitter produces a middling and final tail. The middling fraction is gravity-fed back to the elevator, which conveys raw feed to the Syntron, while the tailing fraction joins the plant magnetic rejects for disposal.

Heat Exchanger: This baffled-fall heat exchanger is 66 in. diam and 15 ft high (including conical sections). The hot exhaust gases enter the bottom and leave the top, passing through the stainless steel duct. They do not come in contact with the ore being heated. The gases enter the heat exchanger at approximately 1800°F and leave at 500°F; the ore enters at 30° to 60°F, depending upon the ambient conditions, and leaves at 250° to 300°F.

Syntron Feed Spreader: The model FC-44 Syntron feeder can handle more than 15 tph and spread feed through a 5-ft opening in a continuous, relatively even curtain of falling feed. It is rated 18 amp at 200 v.

Table IV. Chemical Analysis, Topsham Ore

Element	Pct
SiO_2	73.4
Al_2O_3	15.0
Fe_2O_3	0.07
CaO	0.5
MgO	Trace
Na_2O	2.8
K_2O	8.2
LOI	0.2
	100.2

Table V. Representative Batch-Test Electrostatic Separations on Topsham Ore

Batch Test or Pan No.	Wt, Pct	K_2O, Pct	Na_2O, Pct	Al_2O_3, Pct	SiO_2, Pct
1	10.8	2.2	2.9	8.4	85.1
2	17.6	2.8	3.0	9.2	83.0
3	20.3	6.3	3.1	12.1	78.2
4	21.2	11.0	3.3	16.9	69.0
5, 6, 7, 8	30.1	12.7	3.0	18.5	65.1
Head	—	8.3	3.0	14.0	74.1

Table VI. Screen Assay of Feed, Concentrate, and Tailing

Tyler Mesh	Wt, Pct			K_2O, Pct			SiO_2, Pct		
	Feed	Conc.	Tail	Feed	Conc.	Tail	Feed	Conc.	Tail
+20	8.7	9.4	6.9	8.3	9.8	3.4	76.1	72.4	82.6
20x35	32.4	35.5	24.4	8.4	9.8	2.9	76.5	71.0	85.6
35x48	14.4	13.8	16.0	8.4	10.8	2.8	72.5	66.8	87.5
48x65	10.5	9.8	12.3	8.5	11.2	2.8	71.9	66.3	87.7
65x100	9.9	9.3	11.3	8.2	11.1	2.8	71.5	66.1	84.3
100x200	12.0	12.2	11.6	8.3	11.1	2.7	70.4	66.4	81.0
−200	12.1	10.0	17.4	8.2	10.0	4.2	69.2	68.0	78.1
Head	—	—	—	8.3	10.4	2.9	73.5	69.5	84.0

Table VII. Percentage Chemical Composition of Feed, Concentrate, and Tailing

Element	Feed	Concentrate	Tailing
SiO_2	73.5	69.5	84.0
Na_2O	3.0	2.9	2.8
K_2O	8.3	10.4	2.9
CaO	0.4	0.2	0.4
Fe_2O_3	0.08	0.06	0.10
Al_2O_3	14.3	16.6	8.3
LOI	0.4	0.4	0.4

High Voltage System: This includes the 0 to 100-kv Beta Electric Corp. power supply and control unit, the high voltage insulators and high voltage wiring system, and the electrodes. The high voltage wiring system includes some 100 ft of wire (premium spark-plug wire), 16 Lapp post insulators, and two choke coils of approximately 5000 Henrys each suspended from the ceiling of the power supply room by 20-lb test nylon line. The high voltage electrodes consist of two sets of electrodes, 5 ft in horizontal dimensions and 8 ft high. The electrodes are spaced 10 in. apart at the top and 36 in. at the bottom. Individual electrodes are made up of 3-in. aluminum tubes (the lower 4 ft bent on a 10-ft radius) spaced 1 in. apart and hung from a 4½-in. O. D. Lucite header. All tubes are joined electrically. A potential of 70,000 v is applied to the electrodes.

Concentration Tower Unit (Fig. 8): The 10-gage steel shell, which is covered on the outside with ½ in. of insulation, houses several chutes and hoppers. Rougher (upper pass) concentrate and tailings are collected by hoppers that form a chute to allow an even curtain of falling ore in the rougher and scavenger (lower pass) section. There are also chutes that combine rougher and scavenger concentrate (as a final concentrate) and scavenger middling chutes that combine with raw feed from the heat exchanger to form rougher (or Syntron) feed. Supports are also included for the Syntron feed spreader, electrodes, and vibratory conveyors, which handle the pilot plant products to waste or to storage.

PROCESS FEATURES

Separation efficiency of the electrostatic section of the Topsham feldspar mill is unaffected by variations of feed rate from 1.5 to 7.5 tph. Because of the limited feed bin capacity and the capacity of conveying equipment away from the electrostatic unit, an extended plant run in excess of 7.5 tph has not been made.

Voltage Requirements: After extensive tests at Topsham it was found that the high voltage power supply, which was adequate for test purposes at Mulberry, was not rugged enough to operate in the dust-filled atmosphere of the feldspar mill and withstand the ever-present vibration. These power supplies were essentially heavy-duty laboratory models with the high voltage produced by a delicately tuned radio frequency oscillator and a light duty RF rectifier (1B3 electronic tube) in a voltage tripler circuit. The alternative was to install, if possible, a stronger and more mechanically rugged power supply with more current available at higher voltages. Following installation of Beta Electric Corp. model 2068, 0 to 100 kv, there was no further difficulty in maintaining the necessary potential of 70 kv at the electrodes.

Temperatures: During operations the firebox exhaust temperature ranged from 1850°F to a maximum of 1900°F. This produced an ore temperature of 240°F (plus or minus 15°) at the Syntron feeding the electrostatic unit. A portion of the firebox exhaust gases was introduced into the elevator feeding the electrostatic unit, and the remainder was introduced directly into the electrostatic tower itself. The result was a relatively constant temperature of 155°F in the top of the tower and 135°F in the lower portions of the tower within half an hour after start-up. These temperatures were varied by introducing cold air at the bottom of the tower and also by adding space heaters. However, the temperatures mentioned (155°F in the top, 135°F at the bottom, and 240°F ore temperature) were found to be optimum. (Refer to Figs. 9 and 10).

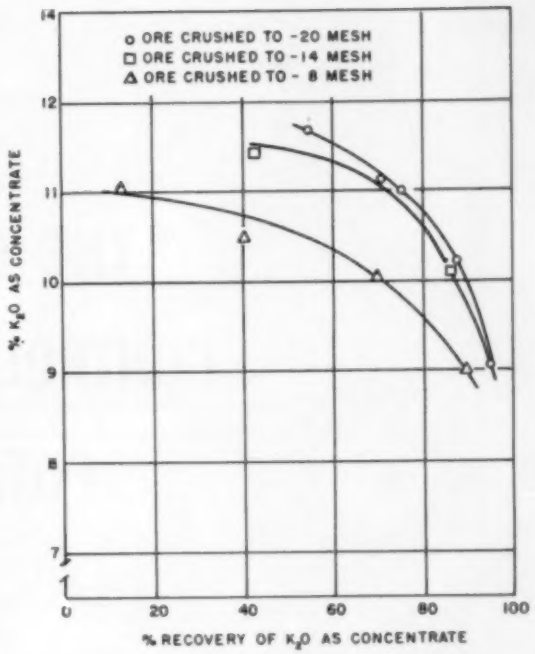


Fig. 11—Static separations of Topsham ore crushed to 8, 14, and 20 mesh. The 14-mesh grind was selected.

Mesh of Grind: To determine the maximum mesh grind for most efficient operation, several tests were made on 8, 10, 14, and 20 mesh. The best metallurgical results were obtained from a 20-mesh grind, but going this fine on the Symons cone crusher presented tonnage problems and raised too much dust, and the next best grind (14 mesh) was adopted as optimum. The relationship between the various grinds is presented in Fig. 11.

Process Control: Process control is attained by use of a geiger counter to determine the K_2O value as a function of the K^{40} isotope. In many instances the variation in geiger K_2O analysis has proved less than corresponding chemical analysis for K_2O.

After the burner is lighted and the conveying equipment and feeders are started, the only attention necessary is to take a sample every half hour and place it in a geiger tube for counting. No extra labor is needed—the two men ordinarily required to run the mill can also operate the electrostatic unit. If any variations from standard grade of concentrate are indicated by the geiger counter, the unit can be realigned by a simple movement of divider setting.

Representative data for the electrostatic process are presented in Tables VI and VII.

REFERENCE

[1] R. B. Ladoo: *Nonmetallic Minerals*, 2nd ed., p. 205, McGraw-Hill Book Co. Inc., New York, 1951.

Discussion of this article sent (2 copies) to AIME before Nov. 30, 1958, will be published in MINING ENGINEERING.

THE GEIGER COUNTER AS A CONTROL TOOL IN PROCESSING POTASSIUM-BEARING ORES

by W. C. KNOPF and G. SAMSEL

For several years International Minerals & Chemical Corp. has used a radiation method to assay potassium content of products from potash and feldspar beneficiation. The procedure is rapid, accurate, and inexpensive and is easily handled, if necessary, by nontechnical personnel. Data are presented to show the accuracies that may be expected if the technique is used for control of pilot plants or large-scale plants.

Natural potassium is composed of three isotopes —K^{39}, K^{40}, and K^{41}. Five other isotopes, artificially produced, have been detected. In natural potassium only the K^{40} isotope, with a half life of 1.4×10^9 years, is radioactive. Its modes of decay are beta and gamma rays, positrons, and x-rays. Only the more abundant beta rays, however, are important in radiation measurements using geiger tubes.

Barnes and Salley[1] measured radiation of potassium salts in solution in 1943. Gaudin and Parnell[2] first reported the use of solid salts arranged in a vessel surrounding the β counter in 1948. Later, Scheel[3] used the method to assay potassium content of various crude and finished potash salts.

Experimental: Dip-type Geiger-Muller tubes (TGC-5) supplied by Tracerlab Co. were used in all radiation counting measurements. The tube was encompassed by a glass container about ½ in. larger in diameter than the tube. This container, which served as a sample holder, was closed at the bottom with a rubber stopper to facilitate removing the samples. Samples were not weighed, but about 40 g of sample were needed for each test.

Electrical impulses from the tube were counted on either a Tracerlab scaler or a rate meter. To obviate the need for constant attendance, preset features were incorporated into the scalers, so that at a predetermined time or count the units were automatically deactivated. When rate meters were used, counting rates were read directly from instrument or from a recorder used in conjunction with the rate meter.

Each tube was calibrated, according to the manufacturer's instructions, to determine the correct operating voltage to insure reproducible results. A linear calibration plot of percent K_2O vs counting rate was also obtained for each tube by recording the counting rate plus background count of several standards of different K_2O content chemically analyzed by the chloroplatinate method.[4] These standards were of approximately the same particle size distribution as samples to be assayed. Specific background count caused by cosmic rays and other surrounding radiation was checked periodically by counting a sample of pure NaCl. Fig. 1 is a representative calibration plot. Assays were determined directly from the standard plot or calculated by subtracting the background count from the counting rate, then multiplying by the slope of the line.

Chemical assays of the test samples were made by the Sherril method,[5] a flame photometric technique, or the chloroplatinate method.

Data: The radiation assay method has been used for three years by International Minerals & Chemical Corp. in the laboratory and in pilot plants processing ores containing potassium. These dry concentration plants process sylvinite and langbeinite ores at Carlsbad, N. M., and feldspar ores at Topsham, Maine.

Sylvinite ore is predominantly a mixture of sylvite (impure KCl) and halite (impure NaCl). Contaminants include sulfates, such as langbeinite ($2MgSO_4 \cdot K_2SO_4$), kieserite ($MgSO_4 \cdot H_2O$), polyhalite ($MgSO_4 \cdot K_2SO_4 \cdot 2CaSO_4 \cdot 2H_2O$), and slimes. Langbeinite ore is predominantly langbeinite and halite with small amounts of sylvite, sulfates other than langbeinite, and slimes.

Several variables, in addition to correct calibration and standardization of tubes, were found to be important in obtaining reproducible results. Particle size distribution of standard samples should be

W. C. KNOPF, Member AIME, is Assistant Director of Research and G. SAMSEL is Senior Research Chemist, Central Research Laboratory of International Minerals & Chemical Corp., Skokie, Ill.
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During a three-year period 1000 measurements of laboratory and pilot plant operations were recorded comparing chemical assays on potassium-bearing ores with those using radiation techniques. Results show that the radiation technique can be readily adapted as a control tool. Variables affecting radiation measurements are discussed.

approximately the same as samples to be assayed. Data in Table I show the effect obtained by assaying samples of different mesh size. The −48+65 mesh fraction was considered a standard with zero error. Measurements using pure KCl vary by as much as 18 pct when different mesh fractions are assayed. Fortunately errors due to particle size distribution can be minimized in practice by calibrating the tube with standard samples of approximately the same particle-size distribution as samples to be assayed in the plant.

Radiometric counting techniques should be recognized strictly as a statistical method. Probable accuracy is a function of the number of counts. The larger the count, the more accurate the results. A useful relationship is the *percent probable error*, which is equivalent to $\frac{67.45}{N}$. Thus if the number of counts for a given sample is increased from 200 to 2000, the probable error drops from 4.8 to 1.5 pct. In the analysis of a 60 pct K_2O potash concentrate, this reduces the probable error from 3 pct K_2O to 0.9 pct. Obviously, the total number of counts should be selected to achieve the desired accuracy. This can be shown clearly by Table II, which gives the spread of actual error as a function of counting time. This data was obtained on a sylvinite concentrate counted ten times at each of the three periods of time. It is apparent that increased counting time improved accuracy of the results.

Wide variation in temperature of the sample during radiation counting can result in erratic data. As an illustration, Table III shows data obtained by repeatedly counting a feldspar concentrate as it cooled from 200°F to room temperature. Counting time for each assay was about 2 min. It can be seen that at first as the sample cooled counting rates increased until the tube and the sample temperatures were approximately in equilibrium. Counting rates then decreased as temperatures approached ambient to reach the 15 pct K_2O value obtained by chemical assay. In addition to the undesirable temperature effect, tube life is shortened by exposure to high temperatures, and after exposure, tubes can rarely be depended on for normal operation. Counting should be done, therefore, with feeds at ambient temperature.

During the three-year period, more than 1000 tests were made in these pilot plants comparing radiation assays with chemical assays. Results of these comparisons are summarized in Table IV. Chemical assays were taken as the basis of comparison in determining deviations. Results were derived from raw data with maximum differences as high as 7.9 pct K_2O recorded for sylvinite concentrates, and as high as 3.9 pct K_2O for tailings of 1 to 5 pct K_2O, overall range. In spite of this, the arithmetic mean difference for all tests was 0.8 pct K_2O and the algebraic mean difference was 0.21 pct K_2O. These differences would have been less except for the fact that values for sylvinite rougher concentrates and feed, Table IV, were exceptionally high. These large values may be accounted for in part by some laxness of personnel, since the importance of accurate assays for control at these

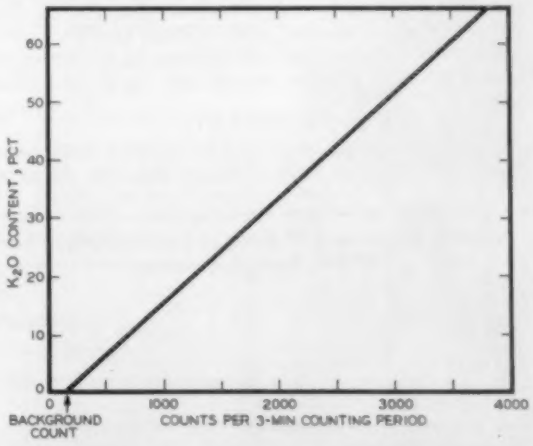

Fig. 1—Counts observed vs K_2O content of ore assayed.

Table I. Effect of Particle Size of Pure KCl on Measured Radiation Activity

Mesh	Cpm*	K_2O by Count, Pct	Error, Pct
−45+65	1040	63.2	0
−28+48	1010	61.4	2.8
−18+28	960	58.3	7.8
−12+18	860	52.0	17.7

* Counts per minute.

points in the pilot plant circuit has not been stressed.

Arithmetic mean differences for all sylvinite fractions was 1.4 pct K_2O, and the algebraic mean difference was −0.6 pct K_2O. Arithmetic mean differences for langbeinite and feldspar fractions were 0.8 pct K_2O and 0.5 pct K_2O, respectively. The increased accuracy obtained with feldspar is attributed to a longer counting time. Feldspar was counted for 10 min, whereas Carlsbad samples were counted for 3 min. This shorter period was necessitated by a shortage of operating personnel. Algebraic mean differences for langbeinite and feldspar products were −0.1 pct and +0.2 pct K_2O, respectively.

Table II. Effect of Counting Time on K_2O Assay of Sylvinite Concentrate

	K_2O, Pct					
	Radiation Assay	Deviation from Chemical Assay*	Radiation Assay	Deviation	Radiation Assay	Deviation
	1 Min		4 Min		16 Min	
Arithmetic mean	60.7	1.8	60.9	0.9	61.4	0.3
Algebraic mean	—	−0.7	—	−0.5	—	−0.02

* Chemical assay 61.4 pct K_2O.

Comparison of probable error with experimental error, Table IV, shows the two values to be fairly close for concentrates, particularly sylvinite final concentrates. This substantiates theory in that more accurate results are obtained where more counts were recorded. Total counts for sylvinite concentrates, for example, were 3000 to 4000, whereas counts for sylvinite tail fractions were 300 to 500. Although experimental error values appear extraordinarily high for tailing fractions, a 25 pct error of a 2 pct K_2O product would only be 0.5 pct K_2O.

SUMMARY

Assays were made on approximately 1000 samples ranging from 1 to 61 pct K_2O by chemical methods and by radiation methods. These pilot plant results show that the radiation technique is satisfactory for control purposes as well as for research or analytical laboratories where a rapid method of analysis is required.

Even with a counting time of 3 min or a total elapsed time of 5 min for each sample, results were accurate enough for control of the pilot plants. Since radiation counting is a statistical method, accuracies could have been improved by increasing the counting time. Even with a substantially longer counting time, the assay technique would be faster than chemical methods, since samples do not have to be weighed or put into solution.

In general it can be expected that the arithmetic mean difference of 0.8 pct K_2O obtained in these tests will be equaled or decreased, as present data include some preliminary results obtained before all the variables were recognized. The arithmetic mean difference of 0.5 pct K_2O assays of feldspathic materials ranging from 3 to 11 pct K_2O indicates the accuracy that might be obtained with a 10-min counting period. This accuracy would be even better, for example, if sylvinite concentrates, which ranged from 55 to 61 pct, were counted for the 10-min period.

Some sources of errors encountered with the radiation method of assay were:

1) Incorrect standardization and calibration of geiger tubes.

2) Variation of particle-size distribution of the test sample with samples used for calibration.

3) Variation of temperature of sample during counting period.

4) Insufficient number of counts to give accurate results.

These variables must be taken into consideration if accurate results are to be obtained with the technique.

Table III. Effect on K_2O Assay of Cooling Sample from 200°F to Room Temperature

Temperature, °F	Cpm	K_2O, Pct
200	344	19.2
—	355	19.8
—	326	17.8
—	322	17.6
—	307	16.8
—	292	15.8
75	281	15.0

Table IV. Summary of Results Obtained From Comparison of Assays by Radiation and by Chemical Methods

Product	Range, Pct K_2O	Probable Error, Pct	Experimental Error, Pct	Mean Difference, Arithmetic Pct K_2O	Algebraic Pct K_2O	Maximum Difference, Pct K_2O
Sylvinite						
Final concentrate	55 to 61	1.2	1.5	0.9	−0.6	7.9
Rougher concentrate	45 to 52	1.3	4.0	1.9	−1.7	4.3
Feed	12 to 19	2.5	9.2	1.4	−0.7	4.4
Tailings	1 to 5	4.5	25.1	0.9	−0.5	3.9
Langbeinite						
Concentrate	18 to 22	1.8	3.8	0.8	−0.1	4.3
Feldspar						
Concentrate	9 to 11	1.5	5.2	0.5	−0.2	1.8
Feed	6 to 9	1.8	6.3	0.5	−0.04	1.5
Tailings	3 to 5	2.1	10.7	0.5	−0.07	1.3

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Discussion of this article sent (2 copies) to AIME before Nov. 30, 1958, will be published in MINING ENGINEERING.

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Reports of Your Technical Society

Planning to travel? For data on many forthcoming meetings, see pp. 1099 and 1105.

NEWSLETTERS . . .

- Coal page 1105
- IndMD page 1103
- MBD'ers Digest page 1107
- Rock in the Box page 1101

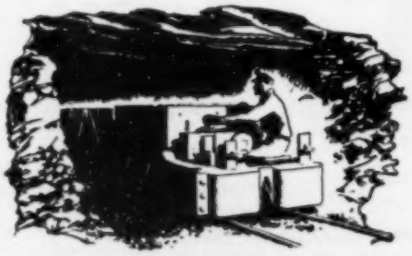
"Meet Me in St. Louie, Louie!"

Mid-America Minerals Conference, October 23 to 25

M B D ers—The cartoon to the left, publicizing the Mid-America Minerals Conference, is appropriate for this issue. The two characters are familiar ones to MBD'ers through their Newsletter. This month marks the inauguration of a new feature—*MBD'ers Digest*, p. 1107—a capsule of items from the Newsletter.

The strength of an organization is directly proportional to its ability to grow. Therefore, growth becomes the concern of every person who belongs to that organization. Increasing membership is SME's key to strength and membership is the responsibility of everyone who belongs to the Society. October is Local Section guest month and your job is to bring a nonmember; introduce him to SME; help him fill out the membership application on pp. 1109 and 1110. Remember—**Every Mining Man should belong to SME of AIME.**

Help welcome new members to Local Section affairs. See the list on p. 1119 for new members in your area.



Get first-hand information on developments in fuels technology at the AIME-ASME Joint Solid Fuels Conference, Old Point Comfort, Va., on October 9 and 10.

MINING ENGINEERING **"firsts"** in this issue: *Abstracts*, p. 1038; *Education*, p. 1102; and *Scholarships*, p. 1104. Do you keep a reference file on articles published in MINING ENGINEERING? The abstracts can be easily clipped for a permanent card file. Also included are abstracts of papers presented at SME meetings. *Education* and *Scholarships* contain current news items from these fields.

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These forms appear on page 1112 for your convenience

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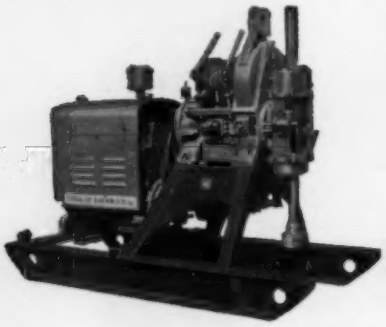

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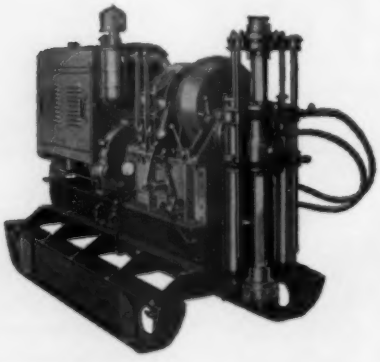

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International Geology Congress in 1960 Will Tour the Viking Land

The 21st session of the International Geological Congress will be held Aug. 15 to 25, 1960. Extensive planning has been started to promote attendance and arrange for papers, excursions, and transportation involved in the meeting. The president of the Organizing Committee is Arne Noe-Nygaard of Denmark, and the general secretary is Theodor Sorgenfrei.

Sessional meetings will be held in Copenhagen at the Mineralogical-Geological Museum. A vast variety of sections of the Congress will cover topics ranging from geochemical cycles, genetic problems of uranium and thorium deposits, and structure of the earth's crust, to submarine geology.

Abstracts of papers to be presented must be received by the general secretary before Apr. 1, 1959. The complete text must be received, ready for publication, by Sept. 1, 1959. Abstracts must be in one of the official languages of the Congress (English, French, German, Italian, Russian, and Spanish), and must be not more than 200 words in length, accompanied by an English translation.

Geologists, geographers, mining engineers, and others who devote themselves to the study or practice of some branch of geology are especially invited to attend the conference, though no professional title is required for membership. The fee is $25 for attending members and $20 for nonattending members. A second circular of information was sent to those who wrote to the general secretary before Oct. 1, 1958.

The International Paleontological Union and The Assn. of Sedimentary Petrologists will hold meetings simultaneously with the Congress. And before and after the meetings there will be excursions to Greenland, Iceland, Norway, Sweden, Finland, and Denmark to study the geologic formations. Interesting pre-Cambrian metamorphic rocks; tertiary, pleistocene, and recent igneous rocks; volcanoes, and related phenomena; tectonic structures, pliocene and interglacial sediments, glaciers, and glacial deposits can all be studied on the organized trips to Greenland and Iceland. Transportation by train, plane, and bus will be arranged, and the groups will be limited for thorough investigations.

The Organizing Committee does not want to receive membership fees at this time but early application is essential. For further information and application forms, write: General Secretary, Organizing Committee, Mineralogisk Museum, Oster Voldgade 7, Copenhagen K, Denmark.

Preliminary Plans For 1959 Pacific Meeting

Plans for the 1959 Pacific Northwest Regional Conference are in the preliminary stage, with meetings scheduled at the Olympic Hotel, Seattle, for next April 16 to 18.

The central committee is composed of the general chairman, Charles R. Low, and his associates, Ralph Watson, Martin L. Plass, and John Judy.

Announcements are being sent to the Local Sections as final decisions concerning the program are made.

Atlanta Meeting Offers Papers Plus Football

Plans are in progress for a fall meeting of the AIME Southeast Section in Atlanta, on Friday and Saturday, November 14 and 15. The meeting will include technical sessions, a field trip, a ladies program, and free time available for the Alabama-Georgia Tech football game for those who are interested.

The formal program, beginning with registration Friday morning, will include a short technical session before the luncheon, and the presentation of interesting papers in the afternoon. A social hour, banquet, and dancing will wind up the day.

On Saturday morning a field trip has been scheduled to observe the Owens-Illinois Glass Co. plant, returning in time for the football game.

Attending wives will be entertained with a tour and tea given by Rich's Inc. department store, among other events.

Complete details will be sent to interested members. Football tickets must be secured individually from Georgia Inst. of Technology. Early reservations are necessary.

January To Be Date For Minnesota Mining Meet

The dates chosen for the Annual Mining Symposium of the University of Minnesota are Jan. 13 and 14, 1959. The AIME Minnesota Section will hold their annual meeting on the preceding day, January 12. Later announcements will cover the program plans.

'59 Annual Meeting Set For Minnesota Section

The Annual Meeting of the Minnesota Section will be held on Jan. 12, 1959.

As usual, in connection with this meeting, the Universtiy of Minnesota announces that the 20th Annual Mining Symposium will be held on Tuesday and Wednesday, January 13 and 14. Headquarters for both meetings will be the Hotel Duluth in the city of Duluth. An interesting program, details of which will be announced later, is being arranged. Stephen E. Erickson is chairman of the Section.

Remember Mid-America Minerals Conference

Don't forget this is the month that spotlights the Mid-America Minerals Conference in the heart of this land. Technical sessions, tours, and city night life are ready for you, October 23. Headquarters will be at the Chase-Park Plaza Hotels in mid St. Louis.

Pittsburgh is Site of Off-The-Record Talks

The Pittsburgh Section of AIME, along with the Pittsburgh Section of the NOHC, are sponsoring the Thirteenth Annual Off-the-Record meeting on November 7. The Program Committee who have planned the Mineral Industries Group sessions are W. M. McKewan, A. S. Russell, C. H. Schweinsberg, and J. H. Melvin. Headquarters for the conference will be the Penn-Sheraton Hotel in Pittsburgh.

Mr. Russell will be co-chairman of the morning session along with E. S. Wheeler. The M. A. Hanna Co. will present a film on iron ore to open the session, and W. E. Knapp, vice president of American Metallurgical Products Co., will discuss *Rare Earth Alloy Steels*, with slides. Malcolm F. Judkins will lecture on *Specific Cermets and Ceramics of Promise*, and a paper on *Boron and Its Applications* will be given by George Huff. The final paper of the morning session is on the topic *Applications of Spectroscopy in a Zinc Smelter*, given by Robert G. Redelfs.

Following luncheon there will be more technical papers, with William M. McKewan and Frank C. Sturges chairing the session. Calumet and Hecla Inc. will show the film *Mine Drainage at Calumet and Hecla* and Robert W. Wilson will discuss *The New Look in Modern Mine Pumps*. James Hyslop will present his paper on *A New Method of Ammonium Nitrate Blasting*. Carlyle Gray, State Geologist, will talk about the activities of the Pennsylvania Geological Survey, and after a brief intermission, another film will be presented, by the International Nickel Co. on *Mining for Nickel*.

Drilling and Blasting Are Themes of Meeting

The Eighth Annual Drilling and Blasting Symposium will take place on October 2 through 4 at the Center for Continuation Study, University of Minnesota in Minneapolis. The conference is divided into five sessions, covering production drilling, drill steels, blasting, research, and a general review.

The papers of the Thursday morning session are *Factors Affecting the Decision to Use Either Vertical or Horizontal Drill Holes in Strip Mining*, by Herschel Hertzog; *Western Practices in the Use of Rotary Air Drills*, by Adolph Soderberg; and *Development of the 9-Inch Down-the-Hole Drillmaster*, by Robert T. Macaul.

In the afternoon two papers are to be presented: *Drill Steel Investigations at Climax Molybdenum Company* by Max Ahrens and *The Metallurgy of Drill Steels* by Howard Chromie.

On Friday morning the papers are: *New Developments in the Use of Ammonium Nitrate as an Explosive*, by Dort F. Tikker; *Developments in the Use of Ammonium Nitrate Explosives in Canada*, by H. E. Farnam, Jr.; *The Present Use and Future Potential of Mili-Second Delay Blasting*, by E. M. Fowler; and *High Speed Photographic Observations in*

(Continued on page 1108)

in Canada . . .

This 40-R drills 7⅞-in. holes at an iron mine in south-central Canada. When moved to this location, it cut drilling costs per foot of hole by more than 50%. One of the features that contributes to the 40-R's fine performance is air bailing of cuttings. Compressed air cools the bit and cleans out cuttings, without need for water. Heavies pile up adjacent to the hole . . . . provide handy stemming material.

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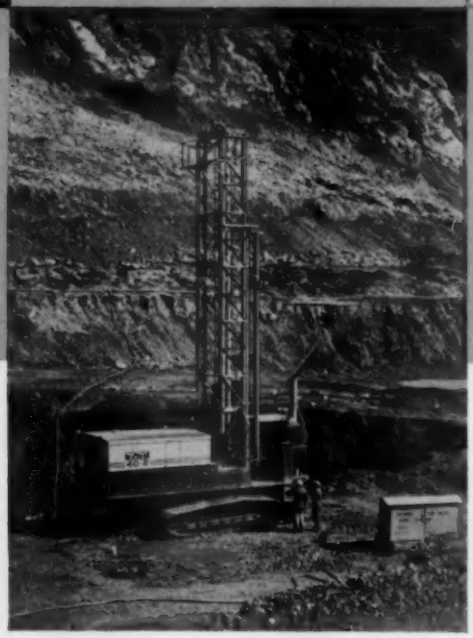

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ROCK IN THE BOX

Mining & Exploration Division

Rock in the Box aims to keep M&E'ers abreast of their Annual Meeting program developments. We also want to introduce you to the men vitally concerned with these plans. In recent issues of the newsletter you have heard of Geology, Geochemistry, and Geophysics Unit program preparations and this month we have news from Open Pit and Underground. These two units got off to a late start but are off and running hard. By the time you get this issue the two mining units will probably be even with, if not ahead of the other units in plans for the San Francisco meeting.

Underground Mining

S. K. Droubay has announced tentative plans for Annual Meeting sessions for his Underground Mining Unit. One session will cover Health, Safety and Personnel, headed by co-chairmen James Westfield and Cliff S. Gibson, who are respectively assistant director of health and safety for the U. S. Bureau of Mines, and safety director, Mines Accident Prevention Assn., Ontario, Canada. Three of the four papers have not as yet been scheduled, but the first paper will be on *Safety and Industrial Hygiene at Braden Copper Co., Chile* by Stanley M. Jarrett.

Another session will cover underground mining in two sections. Richard S. Newlin, vice president of Anaconda, and Frank Coolbaugh, vice president of Climax Molybdenum Co., will be the chairmen. Two papers lined up to date will be *Underground Mining Methods at Gaspe Copper Co., Quebec, Canada*, by W. Brissenden and *Long Hole Drilling as an Aid to Mining Lead Zinc Ores of the Park City, Utah, District*, by G. W. DeLaMare, the general superintendent.

The second section of the Underground Mining sessions will be chairmaned by A. H. Shoemaker, vice president of Homestake Mining Co., and Mayer G. Hansen of the E. J. Longyear Co. Two of the scheduled papers will be *Ambrosia Lake Mining Problems* and *Pillar Recovery at the Mi Vida Mine*, the latter by Virgil Bilyeu.

Open Pit

The program chairman for the Open Pit Unit of the San Francisco Meeting, J. C. Van De Water, has announced the tentative plans for the two open pit sessions. One session will deal principally with drilling and blasting. The second will be concerned chiefly with loading and haulage equipment. It has been planned that each session will have one paper on an open pit operation, at least one of which on a South American operation. The tentative program has been sent to R. J. Lacy and the other members of the M&E Program Committee for their comments. When they have added their suggestions and approval, the program will begin to take final shape.

Introducing—

The program chairman for the Underground Mining Unit is **S. K. Droubay,** the general manager of United Park City Mines Co. He was

born in Toole, Utah, and graduated from the University of Utah in 1926 with a B.S. in mining and metallurgy. He began work with the United Verde Copper Co. in Jerome, Ariz., as junior engineer, sampler, geological draftsman, miner, and finally underground boss. In 1933 he worked for the Original Sixteen to One Mining Co. in Allegheny, Calif. He was chief geologist for Walker Mining Co. and a geologist for International Smelting & Refining Co., and worked for The Anaconda Co. in California, Nevada, Oregon, Montana, and Utah. For his present firm he spent seven years as mucker, miner, and timberman, then moved on through bossing, engineering, geology, chief engineer-geologist, mine superintendent, to his present position.

J. C. Van De Water is the program chairman of the Open Pit Unit. Born in Ellsworth, Kan., he graduated from New Mexico School of Mines in 1929 and started work with St. Joseph Lead Co., underground. He was transferred from shop to shop and in 1930 became assistant mine surveyor at the Rivermines Engineering Office. He remained there

(Continued on page 1102)

S. K. DROUBAY

J. C. VAN DE WATER

J. S. SUMNER

Education News

Pennsylvania State University

A new advance in research and experimentation has been made possible by a donation of the Joy Manufacturing Co. of Pittsburgh to the Pennsylvania State University. The Department of Mining has been provided with a powerful, variable-pitch mine fan valued at several thousand dollars for the ventilation laboratory.

Through the efforts of Hugo Nyquist, vice president of Joy and a graduate of the university, the company made the substantial donation to Howard L. Hartmann, head of the department.

The installation of the new fan is now complete. Dr. Hartmann explained that this addition to their facilities enables the department to conduct mine ventilation laboratory experiments and research that no other university in the country is equipped to do. He stated that the initiation of new research aimed at gaining a better understanding of ways and means of controlling the mine atmosphere is already under consideration.

Colorado School of Mines

Eight faculty members have been raised in rank this September. All hold either doctor of science or doctor of philosophy degrees. N. Cyril Schieltz was raised to full professor of metallurgical engineering. Named as associate professors were John D. Haun, James Merrin, Arthur R. Williams, and John T. Williams.

Raised to the rank of assistant professor were Robert S. Hufstedler, Donald C. B. Marsh, and Lawrence Ogden.

Missouri School of Mines

The Missouri School of Mines will be one of the leading educational institutions in the field of atomic energy training with a new program made possible by the Atomic Energy Commission. The Commission has granted nearly $300,000 to MSM for a nuclear engineering program. The state legislature has implemented the program with $50,000 to erect a building to house the atomic reactor made possible by the AEC.

Only two other universities have received similar grants, the University of California and Ohio State University. The AEC will consider lending 4 kg of contained U-235 for the training reactor core without charge to MSM. This would make possible immediate operation as soon as installation is completed. The new reactor will be of a 10-kw capacity.

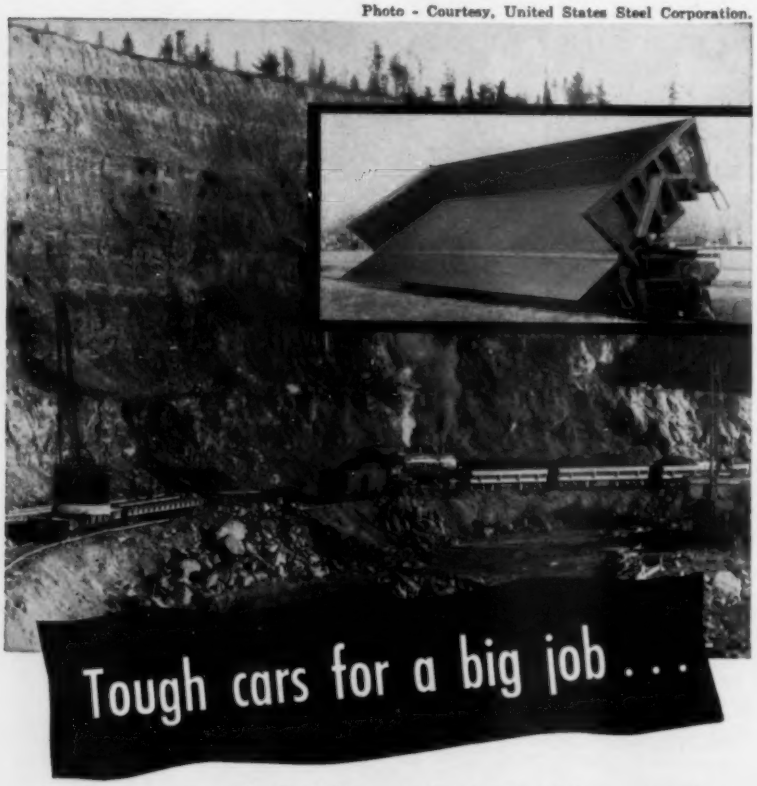
Rock in the Box

(Continued from page 1101)

as mine surveyor until 1937, when he began his first open pit operations at Chuquicamata, Chile, with The Anaconda Co. He shared in the development and mining of the Castle Dome ore body until the latter years of its life, as assistant superintendent and superintendent, 1943 to 1952. He joined Kennecott at the Ray Mines Div. as mine superintendent in 1952 in charge of the open pit development and the final years of the underground operation. Presently he is general superintendent of mines at Ray.

One of the M&E session chairmen is a member of the Geophysics Unit Program Committee. He is **John S. Sumner,** chief geophysicist for Phelps Dodge Corp. in Douglas, Ariz. Mr. Sumner has received degrees in physics and geology from the University of Minnesota and a Ph.D. from the University of Wisconsin in 1955. He served in the U. S. Marine Corps during World War II and in Korea as a fighter pilot. He has been associated with the Cleveland-Cliffs Iron Co., Jones & Laughlin Steel Corp., and McPhar Geophysics Inc. in his career in mining geophysics. His present address is Post Office Box 991, Douglas, Ariz.

Photo - Courtesy, United States Steel Corporation.



Tough cars for a big job . . .

In 65 years or so the first dipper hole at Mesabi has grown to the tremendous open pit pictured here in part. Differential Air Dump Cars first put in appearance at Mesabi in 1925. Veterans of many years and thousands of tons, these cars have carried their loads uncomplainingly. Steady reorders have a pleasant way of nodding approval. We would be glad to tell you more about Differentials — how they're made and why you'll like them.

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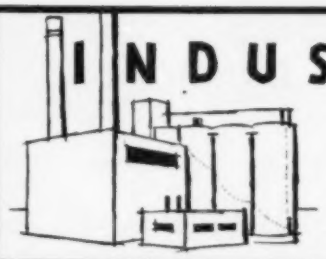


INDUSTRIAL MINERALS NEWSLETTER

Dear Members of IndMD:

The fall issue of the IndMD Newsletter, for which copy is submitted in August, has for the past few years been devoted to odds and ends of new developments dealing with industrial minerals, based on information supplied by your Commodity Chairmen. This year Leon Dupuy, Industrial Waters; John Holland, Chemical Raw Materials; E. L. Howard, Mineral Aggregates, and Dick Jahns, Rare & Radioactive Minerals, have pitched in to supply "up to data."

Groundwater-Land Subsidence

There seems to be more and more interest in the relation between groundwater and land subsidence, both with respect to the surface and underground. Two papers at the February meeting in San Francisco will be devoted to this important relationship and we believe that these will stimulate others to make later contributions.

Sand and Gravel

Ed Howard explains that to those who work with sand and gravel "there is nothing new under the sun." Geologically speaking, of course (and I always do), that is true, but he has called our attention to two somewhat related specific changes proposed for general use in concrete aggregates that may have marked effect on handling methods.

The first will appear in a report of the committee of the concrete institute dealing with measuring and mixing of concrete materials. They propose that finish screening be adopted as a general practice, which means that a vibratory screen be placed above the batch plant to remove breakage and contamination just before the aggregate reaches the weigh-hopper. Enforcement of this proposed specification will require the addition of screens to all existing ready-mixed concrete plants.

The second concerns the cleanness of aggregate delivered to batch plants. Some highway departments have developed tests and set up specifications to measure the cleanness of the rock. By use of various types of scrubbers, washing, and rinsing devices, most gravel producers can meet specifications. However, later tests at the batching plant weigh-hopper may show that the aggregates have degraded either by poor handling or in spite of careful handling methods so that they have accumulated a surface coating of clay-like material. In most cases these aggregates meet all other standard requirements for concrete and have been used in the past very satisfactorily. Local and regional disagreements now in progress are whether to modify the specifications or hold to them so that those aggregates that degrade in handling will be eliminated. This could have serious effects throughout the industry.

Rare and Radioactive

The two "B's" of rare and radioactive minerals are hot these days. There is much activity both with respect to beryl and boron. Government agencies are pushing research and investigations of reserves while many companies are spending large sums in prospecting and development, especially in Colorado, New Mexico, and South Dakota.

It looks as though the price of beryl will remain at a very high level. It is reported that the Colorado School of Mines Research Foundation has developed a successful economic milling procedure for low-grade ores, and that a pilot mill in the Crystal Mountain district of Colorado is doing well.

Borazon (synthetic cubic boron nitride) has been definitely shown to be fully as hard as the diamond and with vectorial hardness differences probably analogous to those in the diamond. Aside from its present industrial use there is some chance that borazon may have gem uses.

Gems—Synthetic and Real

Speaking of diamonds and gems in general, General Electric continues research on synthetic diamonds with encouraging results, but continuing high costs.

At the other end of the scale, from the huge presses of the General Electric Laboratories is a note that skin divers are doing pretty well in recovering boulders of jade along the California coast south of San Francisco. Some of this material is being exported to the Orient.

Of interest to lapidarists and mineral collectors is that the old Himalaya mine in San Diego County, Calif., has been reopened for the first time since 1914 and that in the last five months an excellent quality of pink and green tourmaline has been extracted.

Pegmatite exploration, induced by current high prices for sheet mica of good quality, has promoted revival of mining, especially in North Carolina. Work in Virginia and Maine has led to discovery of gem deposits of moonstone and green tourmaline, respectively.

On the synthetic front both lithium fluoride and calcium fluoride are finding more and more optical uses, mostly based on their high transmission in the infrared and ultraviolet part of the spectrum. Cut gems coated with fluoride (for high brilliance) are appearing on the market in considerable numbers, mainly imported from Germany.

Titanium Dioxide

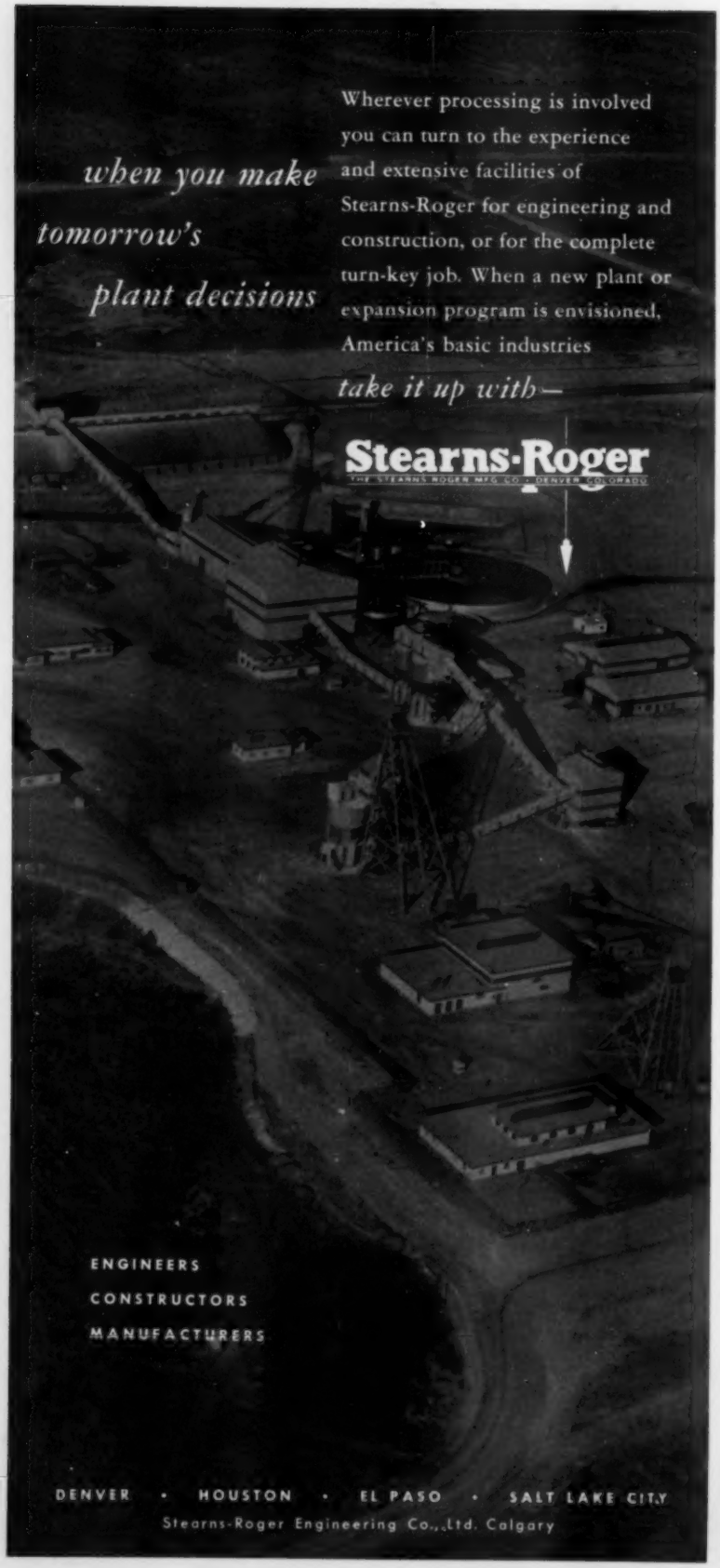
A new development in the use of titanium dioxide pigment is as an aid in curing of concrete, particularly highways. Instead of using a cover of hay, straw, or similar material which must be kept moist, titanium pigment, along with any one of several vehicles, is applied to the concrete surface. The pigment apparently assists in controlling the rate of water loss in such a way as to permit the concrete to cure properly.

Canadian Uranium

The Geological Survey of Canada has completed a detailed field and laboratory study of uranium deposits in the Halliburton-Bancroft district of Ontario. Uraninite and uranothorite are the principal ore minerals. Reserves of commercial promise are reported and work has been done to determine the feasibility of recovering byproduct thorium, rare earths, and zircon.

Editor's Aside

Suggestions are still solicited, but not expected, for the letterhead appearing above this column. The next issue will be devoted to events dealing with the Annual Meeting. Let's hope that Bob Grogan will have returned from safari by then!—*John G. Broughton.*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Scholarships

Joy Manufacturing Co.

Three scholarships totaling $9000 have been awarded to college students by Joy Manufacturing Co., Pittsburgh. Two are awarded annually to the children of employees and the third went to a student who was working for the company during the summer.

Hecla-Bunker Hill

Scholarships totaling $7,250 have been awarded to 38 University of Idaho students and one student at North Idaho Junior College from the Hecla-Bunker Hill fund. These awards are made annually from a $100,000 fund established by Hecla Mining Co. and the Bunker Hill Co. in 1951.

Scholarships are awarded to sons and daughters of employees and to student employees, without any specifications concerning fields of study. Other worthy students who are majoring in mining, geological, or metallurgical engineering and related fields may also be eligible for scholarships regardless of whether they or their parents are employed by the companies.

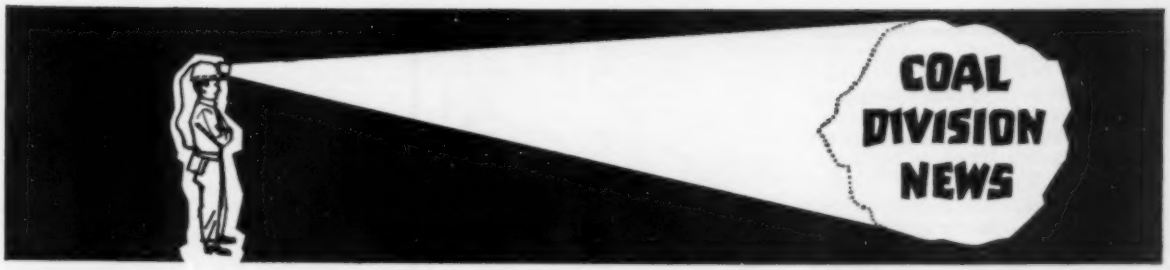
Lead Industries Assn.

Grants to establish two new graduate fellowships in widely divergent fields of ceramics have been provided by the Lead Industries Assn. One fellowship will deal with the use of lead in ferroelectrics and will be at the University of California. The other will be a study of lead glazes on structural clay products at Clemson Agricultural College in South Carolina.

The Lead Industries Assn. has established nine fellowships in ceramics. It is hoped that these research projects will add materially to knowledge helpful to the ceramic industries and assist in making the best use of the unique properties of lead compounds.

Princess Elkhorn Coal Co.

The 14th annual scholarship awards of the Princess Elkhorn Coal Co., David, Ky., have been given to five graduating high school seniors in Floyd and Johnson Counties, bringing to a total of 60 the number of grants donated over the years. During the past year 11 students attended college with assistance from the company. Forty-four seniors, representing 12 high schools, competed for the five awards.



The Coal Division is actively concerned with the growth of the engineering profession, and the recognition of AIME as an important instrument in industry leadership. As the only organization where individual engineers may earn membership, the Institute offers a wealth of values in national and local news, large and small-scale meetings, and continual association with other responsible engineers in a Society which fosters the growth of science and industry.

But this growth depends on the personal contact for which the Society is very well known. It depends on individual concern for fellow engineers who have not been acquainted with the advantages of membership. It is up to each member to extend this personal invitation, to endorse the Institute's welcome, and to offer the first step in AIME hospitality—on a person to person basis. Get *your* colleague to fill out the membership application on pp. 1109 and 1110.

Perhaps the most important large-scale meeting of the Institute is the Annual Meeting to be held in San Francisco next February. The Program Committee of the Coal Division is planning seven technical sessions, each under the careful organization of the individual subcommittees.

So far the program has been designed to provide two preparation sessions, one session on mining methods, one on safety, utilization, and one on carbonization. All sessions but one have been outlined to date. Three or four papers will be included in each with discussion from the floor. Exact titles of the papers are not yet available, but acceptances have been received from the authors contacted.

The Program Committee has endeavored to keep in mind the fact that there will be a large attendance from the western states, and has tried to pattern the program so that it will be interesting to this group as well as to the people from the eastern coal-producing states. There will be a good cross section of the coal industry represented by the speakers at this meeting.

As now planned, each session will be presided over by the subcommittee chairman of the group responsible for the particular session. The speaker for the Coal Division luncheon will be a very prominent man representing the western segment of the industry.

Preparation in advance of these meetings often includes preprints of the papers to be presented. AIME papers from the Joint Solid Fuels Conference, held this month at Port Comfort, Va., are being pre-printed at SME headquarters. These preprints are available on a coupon basis. The coupon books may be obtained for $5.00 a book (10 coupons) for members or $10.00 for nonmembers. Each coupon entitles the purchaser to one preprint. Mail completed coupons to *Preprints*, Society of Mining Engineers, 29 W. 39th Street, New York 18, N. Y. If you do not have any coupons left, more can be obtained at SME headquarters.

A variety of papers will be presented at this conference. The first morning session will cover the topics: *Coal Level Control and Stoppage Alarms. Design Considerations for Pneumatic Coal Handling System, Specific Problems Connected With Handling and Disposing of Combustion Refuse from Solid Fuels,* and *Dock Handling of Bulk Materials.*

On the second morning the paper subjects will include: *Railroad Car Dumper Coal Sampling, Drying of Coal, Fundamental Studies in Bulk Solid Flow,* and *Free Swelling Index of Bituminous Coals with other Standard Tests.*

The final session will cover the subjects: *First Cyclone Furnace Fired Boiler in the Southeast, Start-up and Operating Experiences of Coal and Delayed Coke Fired Utility Boiler,* and *Low Coke Button Bituminous Anthracite Equipment.*

Abstracts have been received (by MINING ENGINEERING'S September issue deadline) for four of these papers, including one scheduled as an alternate paper on *A Petrographic Investigation of the Causes of Degradation of Sized Coal.* See page 1038 of this issue for the publication of these abstracts and preprint order numbers.

Geologists on Caravan Thru Black Mesa Basin

The New Mexico Geological Soc., with the cooperation of the Arizona Geological Soc., will hold its Ninth Annual Field Conference in the Black Mesa basin of northeastern Arizona. The conference will deal with the general geology, stratigraphy, structure, economic geology, and water resources of the Black Mesa Basin. Dates for the excursion are October 16 through 18, with registration at the El Rancho Hotel in Gallup, N. M., on Wednesday evening, October 15.

On Thursday the group will tour the Painted Desert and Petrified Forest, staying that night at Holbrook, Ariz., where there will be an evening technical session. On Friday they will visit the Hopi villages on the way to Flagstaff, where the Museum of Northern Arizona and the Lowell Observatory will be open for observation in the evening.

On the final day, the caravan will travel from Flagstaff to Echo Cliffs, and will wind up at the rim of the Grand Canyon at noon on Saturday. A post-field trip geologic walking trip down Kalibab trail to Phantom Ranch in the bottom of the Grand Canyon has been arranged for the weekend for those who are interested. An extra $10 covers cost of meals and accommodations.

A guidebook containing a road log will be furnished for the trip, and numerous papers dealing with the regional geology will be included. Transportation is by private car. Meals will be chuck-wagon style most of the way, and motel accommodations have been arranged, with sleeping bag facilities for interested students.

Lake Lahontan Problem Subject for Symposium

The University of Nevada was the scene for the Symposium on Problems of the Lake Lahontan Basin as well as the fifth annual meeting of the Great Basin Archeological Conference, August 26 through 28. A large attendance from all over the West gathered in Reno for the three-day event.

The meetings were held at the Mackay School of Mines and were open to the public. The speakers covered such fields as archeology, geology, anthropology, geography, and paleontology.

The first day was devoted to the Lake Lahontan symposium, sponsored by the Sigma Xi club, the professional scientific research organization on the campus. The purpose of the symposium was to review the work done in the ancient lake basin, the area once covered by a huge pre-historic body of water. The

(Continued on page 1108)

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AIME NEWS

M. J. Kelly Awarded The 1959 John Fritz Medal

Mervin J. Kelly, president of Bell Telephone Laboratories, will be the 1959 recipient of the John Fritz Medal at ceremonies to be scheduled by AIEE.

Dr. Kelly has earned the award for "his achievements in electronics, leadership of a great industrial research laboratory, and contributions to the defense of the country through science and technology." The medal is sponsored jointly by AIEE, AIME, ASCE, and ASME.

Dr. Kelly joined the research division of the Engineering Dept. of Western Electric in 1918 and advanced to director of research in 1936. He became executive vice president in 1944 and president of the laboratories in 1951.

During the war the laboratories converted almost completely to military research under Dr. Kelly's guidance, for which he received the Presidential Certificate of Merit. He has since held positions with the Atomic Energy Commission, the Dept. of Commerce, and the Dept. of Defense, earning many honors in the field of science.

He is also active in the field of education, serving as a trustee of Stevens Inst. of Technology, a life member of the Massachusetts Inst. of Technology Corp., and on many advisory committees. He is a graduate of the Missouri School of Mines and received his Ph.D. from the University of Chicago, along with seven honorary doctorates.

One of his most recent endeavors has been his chairmanship of the industry campaign to raise funds for the United Engineering Center.

His membership in many scientific and professional societies has contributed to the development of science in industry and education as well as to our national defense.

M. J. KELLY

Native dancing will set the mood of relaxed entertainment on the Hawaiian holiday after the Annual Meeting in San Francisco, Feb. 20 to Mar. 1, 1958. Soft breezes and swaying music will help conventioners unwind and forget the bustle of business. Plan now to join the lucky vacationers for tours and fun in the water and sun of the Hawaiian Isles. Write for reservations to Theilig International Tours, Inc., Daily News Plaza, Suite 2111, 400 W. Madison St., Chicago 6, Ill. The total cost for transportation, lodging and food: $585.50 per person. Theilig can give any additional information.

AIME

BOARD OF DIRECTORS

Recent actions taken by the Institute Board of Directors.

► Establishment of a Student Chapter at Marietta College, Marietta, Ohio, has been approved and Bylaws accepted subject to changes suggested.

► D. O. Kennedy has been reappointed AIME representative to the association at the annual meeting of the Joseph A. Holmes Safety Assn.

► Nicholas M. Lazar has been appointed representative of The Metallurgical Society on the ECPD Professional Training Committee.

► E. R. Borcherdt and Otto Herres have been reappointed as AIME representatives for two-year terms on the American Standards Assn. Mining Standards Board.

► Douglas Ragland has been reappointed as representative for a three-year term on the Engineers' Council for Professional Development.

► Ivan A. Given was appointed AIME representative at the Annual Meeting of the Mining Society of Nova Scotia in July.

► LaVern M. Griffith was appointed representative on the ASA, Committee M24, Electrical Equipment in Metal Mines, to replace A. C. Stevenson.

► Use of the word *Columbium* for

(Continued on page 1108)

MBd'ers digest

Embie Dee says: *Make your plans now for the San Francisco Annual Meeting.*

What's In A Name?

"Do we change our name, and if so, to what?" That is the question now facing MBD'ers and one on which they have been asked to vote.

A formal petition for name change was presented at the MBD business meeting during the February Annual Meeting in New York. Plenty of discussion was waged—and continues—on all sides of the question.

Four requirements if a new name is to be established are: 1) that it be short and simple, 2) that it be easy to pronounce in just one way, 3) that it represent the specific business of the division without infringing on established names, and 4) that it retain association with the existing establishment.

The objections to the present name are that it is often misspelled and mispronounced and is falsely interpreted as improvement of the minerals without substantial change. The petitioners suggested the more general term *engineering* as a substitute for the problematic *beneficiation*.

Some members do not want the name changed, or feel that *Mineral Engineering* is so broad it would encompass all AIME members. On the other hand, A. M. Gaudin, commenting in February, approves of the plan to organize along functional lines rather than commodity lines and feels *engineering* would be easily accepted and could be given a specific definition through use.

Others commented during the discussion in February. William Newton also approves of a functional grouping of SME divisions but proposed the name *Mineral Processing Engineers Division*, since *engineering* was unacceptable at an earlier date. Herb Rose made an eloquent plea to retain the name, and S. E. Stein suggested coining the term *mineral-lurgical* for the division.

So now members may vote on the four alternatives: Mineral Engineering Division; Mineral Processing Division; Minerallurgical Division; or to retain the present name.

Froth Flotation

On another subject, plans are progressing for the 50th Anniversary of Froth Flotation in the U. S. for 1961. H. G. Poole, program committee chairman, is considering such suggested papers as the use of sequestering agents, the use of hydroclones, and differential copper-lead flotation, plus proposed papers already submitted by E. J. Pryor and M. Rey on regional histories of flotation. The Committee for France plans a meeting in June, and others in Eastern Europe may be contacted.

Annual Meeting

There are rumors afloat that MBD's Program Committee, under the able chairmanship of Wayne Dowdey, has already transmitted an almost 100 pct complete Annual Meeting program to SME Headquarters.

As it now shapes up, the program includes eight sessions, of which two are joint ones with the Extractive Metallurgy Division of The Metallurgical Society. There are an average of four papers per session. Don't miss next month's *MBD'ers Digest* for a preview.

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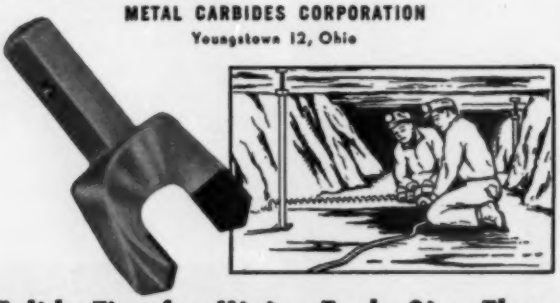

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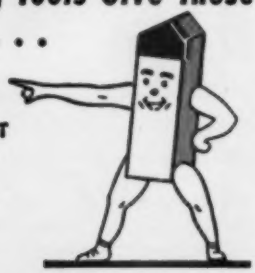

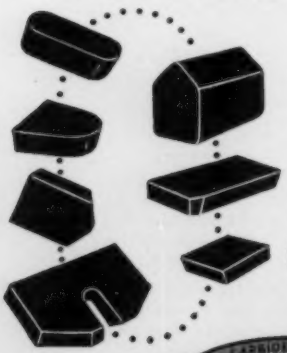

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Board of Directors

(Continued from 1106)

that element in all publications of the Institute was formally designated.

► John P. Nielson was appointed Chairman of the Student Chapter Affairs Committee to replace Robert F. Mehl who will be out of the country for the balance of the year.

► The revised Bylaws of the Southern Nevada Subsection of the Nevada Section were approved, subject to one correction.

► Establishment of the new Wyoming Mining and Metals Section was approved. Bylaws and a list of officers have been received.

► Procedure has been set up for selection of AIME representatives on ECPD standing and inspection committees. Recommendations for ECPD appointments will be made by cooperative action of Societies, Council of Education of AIME, and the Board of Directors.

► The revised Bylaws of the Southern California Petroleum Section have been approved, including a change of name to Los Angeles Basin Section.

Drilling

(Continued from page 1099)

Taconite and Limestone Blasting, by Gordon E. Frantti.

On Friday afternoon the research program presents the following papers: *The Mechanism of Chip Generation*, by John Cheatham; *Energy Transfer in Percussive Drilling*, by Charles Fairhurst; *Stress-Wave Measurements in Underground Blasting*, by Arthur Ruff, and *Explosives Research at Scientific Research Institute*, by George Huber.

The final session in the afternoon is to be a general review, with Lloyd E. Antonides giving a talk on *Review of New Ideas and Techniques in Drilling and Blasting*, followed by a panel discussion with prominent authorities in the fields of open pit and underground operations participating.

Co-sponsors of the symposium along with the host university, are the Colorado School of Mines and Pennsylvania State University.

Nevada

(Continued from page 1105)

Archeological Conference meets annually to discuss the scientific work accomplished there. E. R. Larson was in charge of the symposium.

The second day was mainly concerned with the Archeological Conference, with R. D. Daugherty as chairman. On the third day a field trip had been arranged to tour the Fallon area. President of the Sigma Xi club, host for the meeting, is David B. Slemmons, professor of geology at the school.

Members: Help a Nonmember fill out this handy application—

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Name (Please print) _____ Last Name _____ First _____ Middle

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Your Business Address Where Employed _____

Please State Nature of Company's Business: _____

Professional Title _____ Present Position _____

Address where you desire Society mail to be sent (If not your business address) _____

Born (exact date) _____ at _____ Citizen of _____

ENDORSEMENTS . . . Applications must be endorsed by three AIME Members, Associate Members, or Junior Members who know the applicant personally. Endorser should fill in the spaces to the right of his signature. (Membership in certain other technical societies that have equally high standards of membership may be used in lieu of two endorsers if necessary.)
If you wish the Society to secure the necessary signatures, please list the names of four members who are familiar with your profesional qualifications.

(Print here)	Signature	How long have you known the applicant?	Has he been employed under your supervision?	Grade for which you believe him qualified
Name _____				
Company _____				
Name _____				
Company _____				
Name _____				
Company _____				
Name _____				
Company _____				

EDUCATION Give specific degrees and exact dates. A technical education is not requisite for membership.

	Dates	Degree and Date	Major Subject Or Engineering Field	Minor Subject
Preparatory School _____				
Technical School or College _____				
Graduate Work _____				

If you attended college but did not complete, indicate course taken and number of years completed _____

Be Sure to Fill in Both Sides—Turn the Page

PRIMARY INTEREST FIELDS Please indicate the technical fields in which you are most interested. Mark 1, 2, and 3 in order of preference.

- ☐ Open Pit Mining (Ore)
- ☐ Underground Mining (Ore)
- ☐ Geology
- ☐ Geophysics
- ☐ Geochemistry
- ☐ Coal
  - ☐ Mining
  - ☐ Preparation
  - ☐ Utilization
- ☐ Industrial Minerals
- ☐ Minerals Beneficiation
- ☐ Education
- ☐ Economics

RECORD OF EXPERIENCE

Please list in chronological order a complete record of your employment. Be explicit as to dates, your duties, nature of the work, and the extent to which you were in responsible charge of your own work or of the work of others. Include all positions held, whether or not they are related to the mineral industry. If additional space is needed, use separate sheet of the same size.

Dates From	Dates To	Title of Position, Name of Company Description of your work	Total Time	Time you were in responsible charge*	Name, Title and address of your immediate superior, or of other person familiar with your work

I agree, if elected, to accept election, pay the necessary fees, and to abide by the Constitution and Bylaws.

Do you desire to pay the Entrance Fee in four installments of $5.00 each

Yes _____ No _____

_____
Signature

Date _____

*Responsible for the conduct of technical or engineering work. Employment as a teacher may be so considered responsible for conduct of work.

Around the Sections

• The recently established **Carolina Subsection** of the Southeast Section has announced its officers for 1958-1959. Chairman is David W. Mitchell, and the co-vice chairmen are Ralph C. Flow and Clyde H. Robinson. The secretary-treasurer is Seymour J. Beers and the chairman of the membership committee is Edwin R. Goter. The following men are on the program and arrangements committee: Ralph B. Adair, Earl C. Van Horn, and Joseph N. McClure.

The first meeting was in Asheville, N. C., on April 18, where papers were presented on the topics of waste disposal, core hole deviations, and the use of consultants.

The second meeting was held at Clemson College on June 20. Gilbert Robinson conducted an open house at the Clemson Ceramic Engineering Laboratory and discussed its value to the industry of the Southeast.

• The **Ohio Valley Section** announces its new officers for 1958-1959. The following men have been elected: J. R. Lucas, chairman; J. W. Spretnak, vice chairman; G. H. Schippereit, secretary-treasurer; L. W. Coffer, assistant secretary-treasurer; V. D. Barth, progam chairman; G. K. Manning, membership chairman; and F. J. Barone, Jr., member representative.

• The **Student Chapter** at Ohio State University participated in the annual conference for engineers held on May 2 at the university. William J. Verner was honored by an award of a Lord Elgin pocketwatch for his outstanding record as a senior mining engineering student, a candidate for both B.S. and M.S. degrees this coming December. After graduation he will join North American Coal Corp. The presentation was made by J. Richard Lucas on behalf of the Old Timers' Club.

• The **Southern Sierra Subsection,** Southern California Section, toured the Union Carbide Nuclear Co. Pine Creek mine and mill on June 28. A family picnic at McKinley Park rounded out the day.

• The **MBD Subsection,** Upper Peninsula Section, held its summer meeting at Salvador's Restaurant at Three Lakes, Michigan, on July 24. The group enjoyed cocktails and dinner before an informal talk by John Van Westenburg, assistant professor of metallurgical engineering at Michigan School of Mines and Technology. Mr. Van Westenburg spoke on *Recent Research in the Reduction of Iron Ores.*

Correction

The July issue, page 814, incorrectly stated that the sponsors of the **Adirondack Section's** student essay contest were Republic Steel Corp. and Cabot Carbon Co. In addition to these two companies, the other sponsors of the contest were: National Lead Co., Jones & Laughlin Steel Corp., Gouverneur Talc Co., International Talc Co., the St. Joseph Lead Co., Barton Mines Corp., and Carbola Chemical Co.

William J. Verner proudly accepts the Old Timers' Award watch for his outstanding record as a senior mining engineering student at Ohio State University. Making the presentation is Prof. J. Richard Lucas on behalf of the Old Timers, an organization composed of 30 outstanding coal industry leaders. Observers, left to right, were speakers at the annual conference for engineers: F. M. Morgan, North American Coal Corp.; E. H. Hebden, Jeffrey Manufacturing Co.; Ralph Dean, Lorain Coal & Dock Co.; and Myron Kok, Warner Collieries Co. This Conference took place on May 2.

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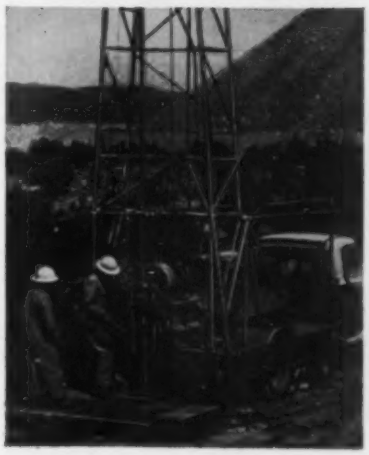

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Personals

W. D. Lord, Jr., is now general superintendent for the Compañia Minera de San José in Mexico, the largest graphite producer in the country. He had been general manager at Republic Metals Co. in Arizona. For the last six months he has been doing consulting and mine examination work.

Frederick R. Jeffrey has been appointed president of the National Zinc Co. Inc. to succeed **Warren H. Leverett,** who is retiring but who will continue as a director of the firm. **Bern F. Buff** becomes general manager.

Morton H. Dorenfeld, formerly with Southwestern Engineering Co., has joined the staff of C. F. Braun & Co., Alhambra, Calif., as senior mineral engineer. He will work as a member of the process engineering group, doing consulting and economic evaluation of ore dressing and metallurgical processes.

R. B. Elver, who received his B.A.Sc. in mining geology from the University of Toronto in 1957 and an M.Sc. in mineral economics at Pennsylvania State University in 1958, is presently doing mineral economics work on iron ore for the Canadian Dept. of Mines & Technical Surveys, Mineral Resources Div., Ottawa.

Douglas Crawford has been with Joy Mfg. Co. since his graduation from the University of Arizona in 1957 and has just been transferred to Grants, N. M., where he is sales engineer for the entire state.

Herbert M. Weisz has returned from Bolivia where he had been general manager of the Empresa Minera Catavi plant for the last eight years. He will be an associate professor at the South Dakota School of Mines & Technology.

Willis M. Johns has been assigned as geologist-in-charge of the field station established in Kalispell by the Montana Bureau of Mines and Geology. This project, known as the Northwest Mineral Resources Survey, is a cooperative venture with the Great Northern Railway and the Pacific Power & Light Cos. Chair-

M. H. DORENFELD

W. M. JOHNS

man of the administrative committee for the five-year survey is **Uuno M. Sahinen,** the Bureau's chief geologist.

Sheldon C. Bergman has transferred from the Mineral Deposits Branch to the Foreign Geology Branch of the U. S. Geological Survey to work on nonmetallic mineral resources with the Philippine Bureau of Mines under an ICA program.

W. R. McDaniel, sales representative for Union Supply Co., has moved to Denver to handle heavy equipment sales.

Jerome H. Remick, who has been a graduate student at the University of Michigan, is now with the Geological Surveys Branch, Dept. of Mines, Quebec, working on geological mapping of the Chibougamau Bachelor Lake copper mining district.

Rogers V. Waugh, formerly administrative assistant for Union Carbide

PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

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Address

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Name of AIME Member:

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CHANGE OF ADDRESS AND PERSONALS FORM

CHANGING YOUR ADDRESS? Don't forget to notify us six (6) weeks before you move, if possible, to insure uninterrupted receipt of your publications and correspondence. Please fill in the form below and send it to: J. F. Lynch, Asst. Treasurer AIME, 29 West 39th Street, New York 18, N. Y.

Name .....

Old Address .....

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New Address .....

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PERSONALS: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Former Company .....

Former Title ..... Length of Time There .....

New Company .....

New Title ..... Date of Change .....

.....

Any recent activity that would be of interest to members:

.....

.....

.....

Ore Co., now is an engineering geologist with the U. S. Army Engineers.

Fred A. Brinker has been appointed assistant vice president of Vanadium Corp. of America. He was formerly chief metallurgist, Western Div.

Robert Lee Evans is beginning research work on dust sampling and counting for the U. S. Bureau of Mines as a mining engineer, Branch of Health Research in Pittsburgh.

Richard S. Newlin, vice president in charge of operations for The Anaconda Co., was named president of the Greene Cananea Copper Co., a subsidiary.

Edward H. Rott, formerly eastern Caribbean regional manager for Joy Mfg. Co., has established the Venezuelan Caribbean, S. A., with headquarters in Caracas, to provide manufacturer's representation service for a limited group of manufacturers. Through Venezuelan Caribbean the group attains service similar to that maintained by larger companies with a resident representative in the region.

L. J. Burrows, Jr., left the Sunshine Mining Co. in Kellogg, Idaho, where he was mining engineer, to found the Northwest Geophysical Co. in partnership with his father. Initially the company will specialize in shallow zone seismology with applications in the engineering and construction fields. The new company's headquarters are in Spokane.

James C. Westbrook, chief of the Contract Finance Branch at the Grand Junction Operations Office of the Atomic Energy Commission, has been awarded a Superior Performance certificate and $300 in cash for an outstanding job in supervising and administering the financial terms of AEC procurement contracts involving millions of dollars annually.

Lyle Mulholland, former Materials Handling general foreman at Kennecott's Chino Mines Div., N. M., has been named convertor general foreman at the Hayden mill. Other new appointments at Kennecott include **Robert McChesney,** chief chemist, and **James Halley,** smelter metallurgist.

Daniel P. Ryan received the professional degree of engineer of mines from the University of Alabama. His thesis topic was *The Use of Ammonium Nitrate as a Commercial Explosive in Limestone.* He is employed by the Hercules Powder Co. and lives in Blanket, Texas.

R. M. Lauer has been appointed superintendent of research and technical control for the Sullivan concentrator, Consolidated Mining & Smelting Co. of Canada Ltd., Kimberly, B. C.

William A. Bowes has moved from Nevada where he was chief of the

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personals

continued

Reno Section, Div. of Raw Materials, U. S. Atomic Energy Commission, to Santiago, Chile, where he is a geologist for the A.E.C. in cooperation with the Instituto de Investigaciones Geologicas.

Arnold H. Miller, consulting engineer, is in Europe on professional business, visiting chiefly Spain, France, and Italy. He is associated with Arnold H. Miller Inc. in New York.

Mr. and Mrs. Merle H. Guise are in Fairbanks, Alaska, where Mr. Guise is concerned with private business. He had walked into Alaska over the Valdez Trail as a boy.

Mark Lintz, mining and metallurgical engineer of Prescott, Ariz., is in the state of Jalisco, Mexico, on professional business.

Arthur Bowling, Jr., is now employed by the Rochester & Pittsburgh Coal Co. as a mining engineer. He had been a student at West Virginia University.

Joseph E. McLean, left, commissioner of the New Jersey Dept. of Conservation and Economic Development extends good wishes to State Geologist **Meredith E. Johnson** *upon his retirement after 30 years in public service.* **Kemble Widmer,** *right, will succeed Mr. Johnson in the position of state geologist and chief of the Bureau of Geology and Topography, as the fifth director of the State Geological Survey, established in 1864.*

Phillip D. Pack, formerly with the State of California Dept. of Water Resources in Sacramento, has accepted the position of senior engineering geologist with Holmes and Narver Inc., engineers-constructors, in Los Angeles.

Joseph I. Horty, editor of Hercules Powder Co.'s magazine *The Explosives Engineer,* and manager of explosives advertising, has retired after 42 years of service with Hercules.

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Mr. Horty was honored at a luncheon for the presentation of the National Safety Council's Public Service Award to his magazine. It is the seventh time in ten years that the magazine has earned this award.

Conrad Fraps, formerly of the University of Arizona, now is employed by American Smelting and Refining Co. in Tuscon, Ariz.

Frank E. Lewis has retired from active service at the Horse Heaven Mine Unit of The Cordero Mining Co. after 20 years with the firm. The Horse Heaven mercury mine has ceased operations.

William G. Caple has moved from Ohio to Montana where he is working in the metallurgical department of American Chrome Co. He had been employed by Battelle Memorial Institute.

Dallas E. Ingersoll is now supervisor and technologist in solid fuels with the U. S. Bureau of Mines. He had been division superintendent for the Philadelphia & Reading Coal & Iron Co.

David O. Pearce, who had been general manager at Falcon Mines Ltd. in Southern Rhodesia, has now advanced from assistant superintendent of mines to assistant general manager for the O'Okiep Copper Co. Ltd. in South Africa, where he has been for the last three years.

Charles D. Shoaf, formerly president of Southern Tool & Engineering Corp., now is evaluation engineer for the U. S. Treasury.

H. Craig Argo, formerly of the Carborundum Metals Co., has joined the Westinghouse Electric Corp. in Philadelphia as metallurgical engineer.

Alvin S. Cohan has been appointed to the newly created public relations position for the Scientific Design Co. Inc., New York. He will be responsible for advertising, sales promotion, and publicity. Mr. Cohan was formerly a public relations executive with J. M. Mathes Inc. He has also been associated with Titanium Metals Corp. of America, and was manager of publications for AIME.

Robert D. Longyear has been appointed to the newly created post of chairman of the board of the E. J. Longyear Co. and **Donald M. Davidson,** vice president of the Mining Div., has been elected president. Mr. Longyear had served as president for 35 years. Mr. Davidson will also assume the leadership of Canadian Longyear Ltd.

A. P. Kibbe, president of Hidden Splendor Mining Co., has been elected a vice president of Uranium Inst. of America.

J. Frank Frost and **W. P. Hewitt** have been elected directors of United Park City Mines Co.

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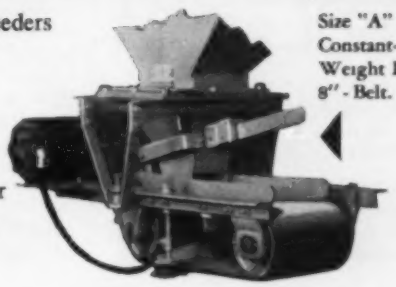

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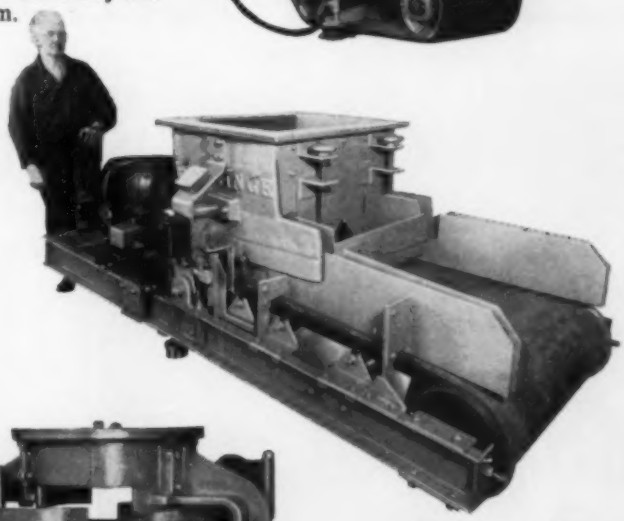

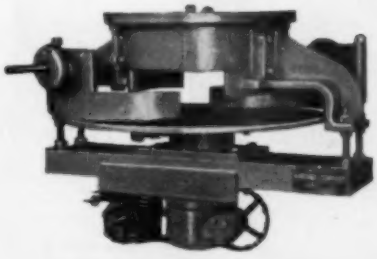

Size "D" Constant-Weight Feeder, 36" - Belt.

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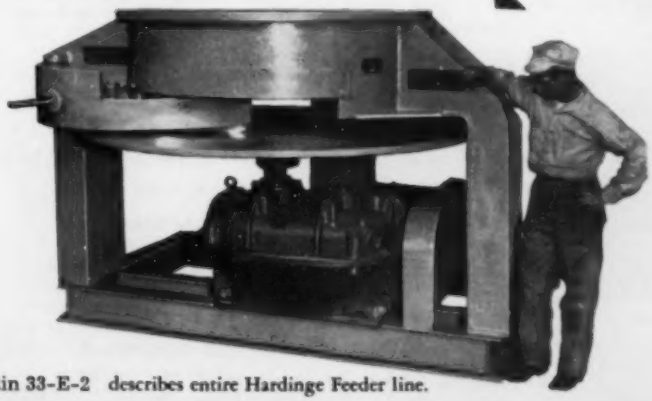

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personals

continued

William McKinnis recently graduated with a degree in mining engineering and is now employed by Sunshine Mining Co. in Kellogg, Idaho.

John W. Finklang, formerly valuation engineer—mining for the U. S. Dept. of Interior, Bureau of Land Management, now is in Richmond Heights, Mo., as a cartographer at the Aeronautical Chart and Information Center.

Solomon Lieb, representative and technical advisor to the Corporacion Minera de Bolivia, resigned to travel in Europe and the Far East as consultant minerals engineer for an investment firm. He returned to his Long Island home during the summer.

E. C. Weichel, Jr., and **Frank M. McKinley** have been elected vice presidents of Humphreys Gold Corp. Mr. Weichel was manager of the two ilmenite-zircon mining plants near Starke, Fla., built and formerly operated by Humphreys for duPont de Nemours and Mr. McKinley was manager of the Humphreys mining plant near Jacksonville, Fla. Mr. McKinley also becomes vice president of Humphreys Engineering Co. with headquarters in Denver. **Lee Dailey** was elected treasurer of both companies. **Judson S. Hubbard** has retired as vice president and treasurer but continues as director of both companies. **Jay P. Wood** is vice president in charge of operations of Humphreys Gold Corp.

Frank J. Chernosky has been discharged from the U. S. Air Force as project officer and is now a graduate student in the mineral dressing, M.S. program, at Michigan College of Mining and Technology.

Charles G. Preble has graduated with a B.S. in meteorology from the Air Force program at Pennsylvania State University and will serve as weather forecaster for the Air Force at Nouasseur AB, Morocco, until his discharge. He was formerly with American Smelting & Refining Co. as a mining engineer.

G. Blaine Standifird, assistant works engineer for the Columbia-Geneva Works, U. S. Steel Corp., has been named works engineer to succeed **W. Truxton Purvance,** who has been made project engineer for U. S. Steel at Pittsburgh.

J. Henkel has become principal technical officer of Commonwealth Scientific & Industrial Research Organization in Victoria, Australia. He had been assistant metallurgist for the Zinc Corp. Ltd. in New South Wales, Australia.

Samuel M. King, who has been in the U. S. Army as first lieutenant, now is an engineer for the American Trucking Assn. He is an observer at the Assho road test in Ottawa, Ill.

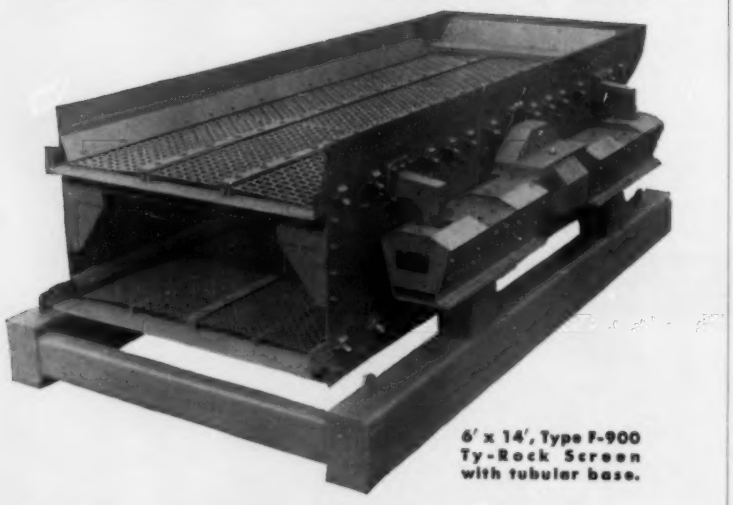
John F. Ivanac, senior geologist for Cerro de Pasco Corp. in Morococha, Peru, has been transferred to Cerro de Pasco where he is in charge of the geology and assay departments.

Hiram B. Humphrey has been honored with the U. S. Dept. of the Interior's Meritorious Service Award and Silver Medal, in recognition of 28 years of exceptional service in the U. S. Bureau of Mines. He retired in August 1957 from the position of mining health and safety engineer in Washington and moved to Menlo Park, Calif.

John P. Hicks has been appointed secretary of the Lehigh-Boone Bituminous Corp., Bethlehem.

M. E. Pratt, Jr. has been transferred to the Lucky Mc Mine, Riverton, Wyoming, of the Utah Mining Corp. where he is assistant manager. He had been superintendent of the Utah Construction Co. in Cedar City, Utah, the parent company.

TY-ROCK SCREENS



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Obituaries

Donald M. Liddell

An Appreciation By
Philip D. Wilson

In his 80th year Lt. Col. Donald M. Liddell, a member since 1916, passed away on Aug. 16, 1958. Colonel Liddell's health had been gradually failing for more than a year, but his fortitude was tremendous. On Jan. 29, 1958, he received the Gold Medal of the Mining and Metallurgical Soc. of America at the Society's annual dinner at the Princeton Club of New York. On this occasion he made an extraordinary speech of acceptance of the richly deserved honor, in which he discussed the history of the medal and the accomplishments of the 14 prior recipients since it was first bestowed jointly on Mr. and Mrs. Herbert Hoover in 1914. Colonel Liddell's citation was "Unusual Contribution to the Art of Non-Ferrous Metallurgy and Research in Connection Therewith."

He was to the day of his death a distinguished metallurgist, starting immediately after his graduation from Johns Hopkins in 1900 in copper and lead smelting and refining, successively in Morenci, Ariz.; Baltimore; Chrome, N. J.; and Graselli, Ind. During and after this period he served on the editorial staff of *Engineering and Mining Journal*, concluding this phase of his career in 1913 to 1916 as managing editor of the magazine. During World War I he served as a captain and in World War II he was a lieutenant colonel in the Army.

From 1919 to 1936 he was a partner in the consulting firm of Weld and Liddell, also acting as president, consulting engineer, and director of numerous corporations during that period. During his later years he served among other activities as director of the National State Bank of Elizabeth, N. J.

Colonel Liddell was early involved in the exploration of the lateritic nickel deposits in Cuba which were subsequently developed by Pardners Mines Corp. and later exploited and operated by the Freeport Sulphur Co. Nicaro Nickel contributed largely during World War II and the Moa Bay project is now being prepared for large production of nickel in a year or so. Colonel Liddell was a director of both the original companies from 1936 to 1942.

He was the author of the *Metallurgists' and Chemists' Handbook* in 1916, which had three editions and the *Handbook of Chemical Engineering* in 1922, with two editions. In 1926 he wrote the *Handbook of Non-Ferrous Metallurgy* with revised editions in 1931 and 1946. He was co-editor with H. Foster Bain in 1922 of *International Control of Mineral Resources;* co-author with Kenneth Leith in 1931 of *Mineral Resources of the United States and its Capacity to Produce;* co-author with Gilbert Doan in 1933 of *Principles of Metallurgy;* and co-author with Jean Maunoury and G. A. Pfeiffer in 1937 of *Chessmen.*

In 1955 Colonel Liddell was elected president of the Mining and Metallurgical Soc. of America, after having served for a number of years as the Society's very efficient secretary. In addition to AIME, he was a member of the Mining Club of New York, of which he was president in 1947 to 1949. He was also an honorary member of the Chemical, Metallurgical and Mining Soc. of South Africa.

Colonel Liddell was blessed with a pleasing personality, which endeared him to a host of friends who will miss him hugely and will mourn his loss. He is survived by his widow, Edith (Stabler) Liddell; one son, Lt. Col. Donald M. Liddell, Jr.; a daughter, Edith (Mrs. J. Russell Twiss); and five grandchildren.

In Memorium

Mildred Esterbrook Mudd, former national president of the Girl Scouts of America, died in Los Angeles on Aug. 23, 1958 after a long illness. She lived in Beverly Hills. Mrs. Mudd was the widow of Harvey Seeley Mudd, mining engineer, who died in 1955. They were married in 1913. She was born in Jersey City and attended the Louise Veltin School in New York. Her work with the Girl Scout movement began in 1934 when she was appointed commissioner of the Los Angeles Council. She was president from 1939 to 1941. In June 1956, Mrs. Harvey Mudd, her son, Henry T. Mudd, and daughter, Mrs. Caryll M. Sprague, contributed over $35,000 to finance the preparation and publication of *Economics of the Mineral Industries.* This volume is to be part of the Seeley W. Mudd Series and, in addition, will be designated as being in memory of Harvey S. Mudd.

Edward M. Norris

An Appreciation By
A. C. Bigley

It is with deep regret that I record the death on May 7, 1958, of E. M. Norris (Member 1914), whom I have known and been associated with for a great many years.

Mr. Norris, known to his numerous friends and associates as *Long John,* was born in Newark, N. J., on Mar. 12, 1883, and served as a civil engineer for the New York Central Railway and as an assayer for the Nova Scotia Gold Mines before his graduation from the School of Mines of Columbia University.

After graduation, Mr. Norris started his career as a miner in the early part of the century, and was a well

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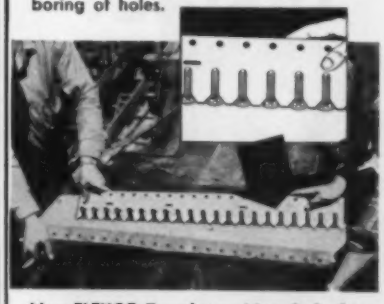

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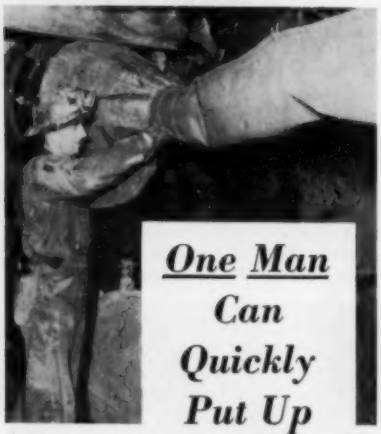

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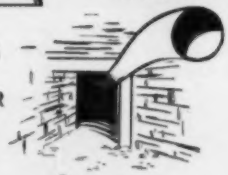

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known and popular mine operator during his time in Butte, Mont. He became widely known for his abilities in mine management capacities and was considered an excellent all-round mining man and engineer. After his retirement from the services of The Anaconda Co., he was called upon frequently as a consultant for various producers of phosphate rock in the west, as he was an expert in this field.

Following his graduation as a mining and metallurgical engineer, he came to Butte in 1905 and started working as a miner for the Parrot Mine. In 1907 he became manager of a property in Nevada, and also acted as a mine inspector in the southwest.

On his return to Butte in 1908, he worked as a shift boss for the Red Metal Co. which was later acquired by Anaconda. In 1910 Mr. Norris became assistant foreman of the Tramway Mine, foreman of this property in 1912, and then was promoted to assistant general superintendent of the Meaderville group of mines on the east side of the Butte Hill in 1917. In January 1928 he was appointed manager of The Anaconda Co.'s phosphate operations at Conda, Idaho, where he was located until his retirement in January 1946.

He was an avid sportsman, and when residing in Butte, was active in the old curling groups and also was a commissioner of the Mines Baseball Groups.

After his retirement he and Mrs. Norris moved to Chula Vista, Calif., but remained in touch with his many friends in the Intermountain area where he visited each summer.

George W. Rathjens (Member 1954) died on Apr. 22, 1958. He had retired in 1948 from U. S. Smelting, Mining & Refining Co. Born in Boston, he received a B.S. in 1910 from the University of Illinois. In 1900 he was chief of party for the Chicago, Great Western Ry. and in 1904 he had been assistant superintendent at the Barber Asphalt Paving Co. He was later resident engineer for Tidewater and Deepwater Ry. before joining Twin City Brick Co. as superintendent. He worked in that position for several years and was elected vice president in 1915. From 1925 to 1944 he worked for U. S. Smelting, Refining and Mining Co. as chief engineer, first of their subsidiary in Alaska and then of the parent company, where he became chief consulting engineer. On military leave from 1942 to 1944 with the U. S. Army, he was district engineer, Greenland District, and chairman of the Price Adjustment Board. He retired as colonel of engineers. He did private consulting work for a few years after his retirement and worked on the manuscript for Polar Engineering Handbook for U. S. Navy in 1953.

Michael P. Cloonan (Member 1924) died on July 15, 1958, on his way to Washington, D. C., in behalf of Colorado lead and zinc business interests. He was manager of the Fluorspar Corp. of Walden, Colo., where he lived. He began his career carrying mail by pony to the Ontario and Daly West Mines in Park City, Utah, in 1907. He had been born in Leadville, Colo., in 1891 where he attended school. He also took the Alexander Hamilton business course in New York. He had worked for the Utah Copper Co., the Yellow Pine Mining Co., the Kirk Siman Smelting Co., and the Spar Mountain Mining Co. in Nevada, California, and Illinois. In 1923 he was a metallurgical engineer for the Fairview Fluospar and Lead Co. in Rosiclare, Ill. For 22 years he had been a mining engineer in Utah mines and mills, and was president of the Colorado Mining Assn. in 1956.

George E. Harike (Member 1954) died on Nov. 28, 1956. He had been assistant director of the research laboratory for Tennessee Corp., College Park, Ga. He was born in Hattiesburg, Miss., in 1908 and went to the University of Alabama where he received a B.S. in chemical engineering in 1929. He worked for Ducktown Chemical & Iron Co., Southern Mineral Products Co., and Tennessee Copper Co. in Virginia and Tennessee before going to Georgia to live.

Clifford McIntosh (Member 1944) died suddenly at his home in Hibbing, Minn., on June 20, 1958. He was manager of mines for the Great Northern Iron Ore Properties. Born in Bottineau, N. D., in 1895, he graduated from high school there and attended the University of North Dakota where he received a degree in mining engineering in 1920. He began with Great Northern as mining engineer at Marble, Minn., and was promoted to chief inspector of the western district in 1929. He transferred to Hibbing in 1946 as chief engineer and later was made manager of mines for the Ore Properties, the position he held at the time of his death. He was also a member of the Minnesota Section of Professional Engineers, and The Engineers Club of Northern Minn.

Kenneth T. Price (Member 1935) died May 13 at Port Sulphur, La., where he had lived since 1934. He was vice president in charge of Louisiana producing operations of Freeport Sulphur Co., the firm he joined in 1925 just after graduation. Mr. Price had attended the University of Texas. In 1930 he became superintendent of scouting and in 1934 was transferred as superintendent of production of Freeport's first mine in Louisiana. He was appointed general superintendent of that property in 1942, became assistant vice president

in 1951, and vice president a year later. Mr. Price was also a member of the Louisiana Engineering Soc. and the Petroleum Club of New Orleans.

Necrology

Date Elected	Name	Date of Death
1903	A. J. Anderson Legion of Honor	July 14, 1958
1944	Henry W. Bauer	May 21, 1958
1914	Oliver Bowles	Aug. 2, 1958
1942	Kenneth C. Brownell	Aug. 4, 1958
1914	William L. Creden	February 1958
1920	William G. Duncan, Jr.	Unknown
1942	Paul B. Earwood	Dec. 16, 1957
1898	William W. Elmer Legion of Honor	Mar. 1, 1957
1957	Frankin A. Flodin	June 20, 1958
1918	Frank F. Grout	Aug. 1, 1958
1905	Robert Hawxhurst, Jr. Legion of Honor	April 1958
1916	Donald M. Liddell	Aug. 16, 1958
1947	Corbin Marsh	May 25, 1958
1924	John B. Platts	Mar. 10, 1958
1903	Gerald Sherman Legion of Honor	May 20, 1958
1930	John P. Skinner	Unknown
1950	C. E. Taylor	June 21, 1958

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Society of Mining Engineers of AIME

Total AIME membership on Aug. 31, 1958, was 30,496; in addition 3,125 Student Members were enrolled.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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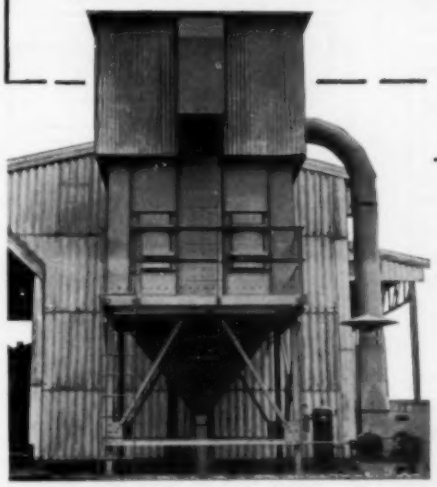

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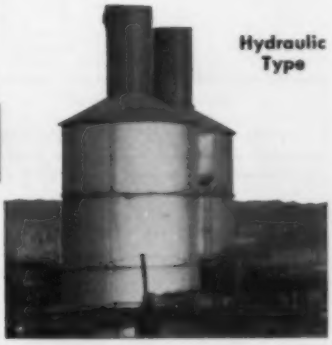

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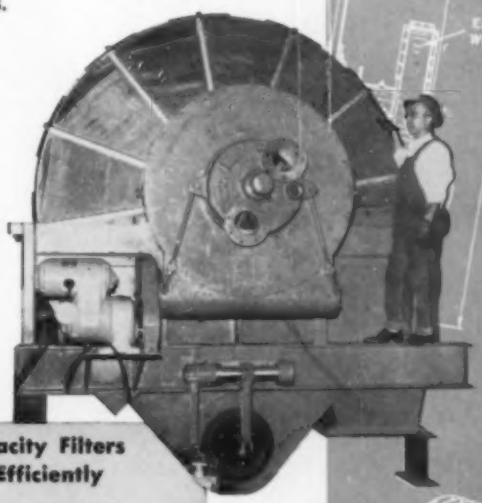

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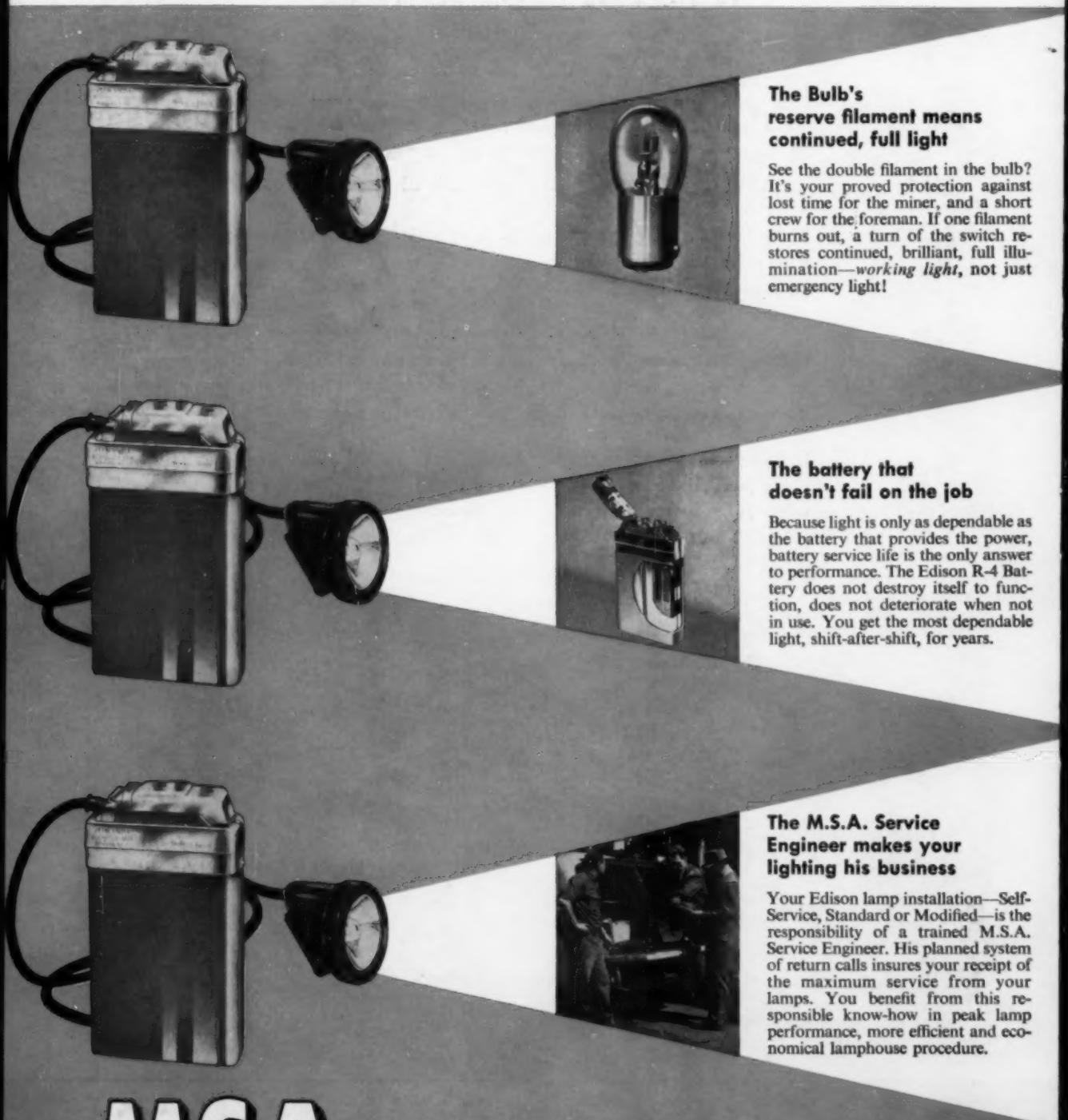

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